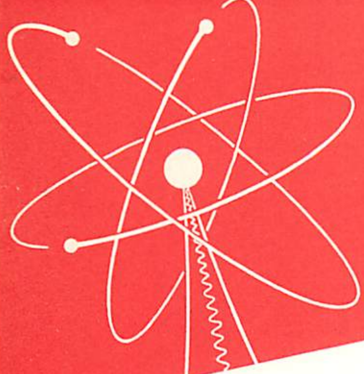

TUNERS

Lesson T2C-4A

DeVRY Technical Institute
4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T2C-4A

VHF TUNERS

4141 Belmont Ave.

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Chicago 41, Illinois

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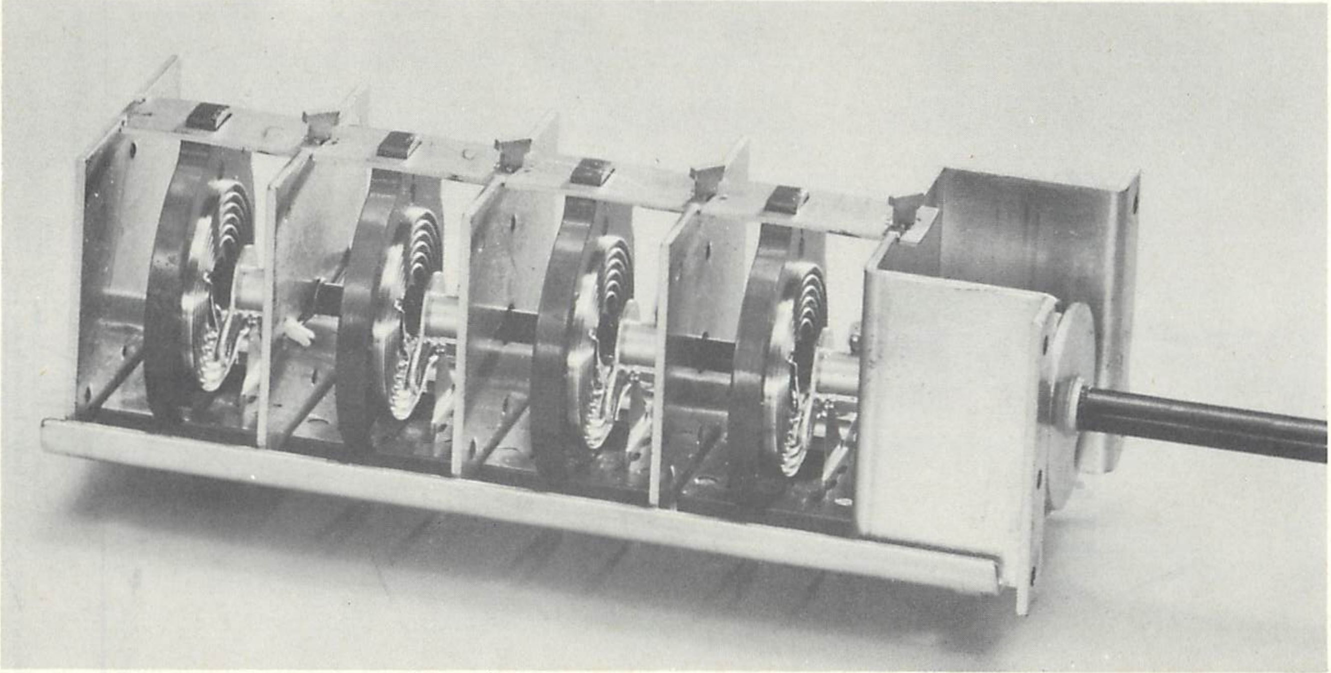

A variable inductance continuous type tuner known as the Spiral Inductuner. Each coil shown has a variable wiper arm which serves as a shorting contact for the coil.

Courtesy P. R. Mallory and Co., Inc.

VHF TUNERS

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Every failure is a step to success; every detection of what is false directs us toward what is true; every trial exhausts some tempting form of error.

—William Whewell

VHF TUNERS

In the preceding lesson we described a number of television tuner fundamental circuits and their characteristics, along with some of the requirements regarding circuit and tube applications. Because of the many intricate mechanical arrangements and exceptional considerations required in the manufacture of television tuners, this field has been given a lot of special attention. As a result, most television receiver manufacturers today have turned to the specialized tuner manufacturer to produce and supply the "front-end" or tuner unit for their receivers. Because of this factor, variations in tuner circuits and assemblies among the many receivers on the market, are not as great as might be expected.

However, there are several distinct types of commercial television VHF tuners in use. It will be the object of this lesson to describe a typical tuner of each type so as to cover most of the VHF tuner arrangements used in television receivers today.

In addition to variations in circuitry, tuners also differ as to the method used for channel selection. There are two basic mechanical methods of station selection. Those tuners using a method of circuit switching from channel to channel are referred to as "detent tuners". They have a mechanical stop or catch arrangement in the switching mechanism for each channel, which affords a positive action for selection and, of necessity, maintains the switching position for accurate circuit contact.

With this selection method the tuning from one channel to the next is accomplished by switching different coils or capacitors, or both into the r-f, mixer, and oscillator circuits.

The second method of channel selection uses some form of continuous tuning from channel to channel. Some of these systems are similar to the tuning arrangements used in radio receivers. This type of tuner is referred to as the "continuous tuner". With this system the inductance or capacitance of the r-f, mixer and oscillator circuits is varied gradually through its reception range.

DETENT TUNERS

Turret Mechanics

One of the basic types of detent tuners uses a drum or turret system of channel selection such as shown in Figure 1.

The tuner drum can be rotated to any one of the 12 VHF channel positions by the selector shaft.

The detent roller and flat steel spring shown in Figure 1A hold the drum firmly in position, so that the coil strip contact points rest squarely against the tuner spring contact panel near the tube sockets. The spring contact panels can be seen in the picture of Figure 1B which shows the tuner right side up; the detent roller and spring are now on the other side of the tuner.

The coil strips with their contacts shown in Figure 1A are easily removable for repair or replacement. This turret tuner actually carries 12 sets of antenna—r-f snap in coil strips and 12 channel matching sets of mixer—oscillator snap in coil strips. In Figure 1C is shown a set of coil strips for channel 9.

The coil strip on the right contains the signal input transformer for the channel. It is made up of the primary center-tapped antenna coil that makes contact with the antenna transmission line to obtain the signal energy, and the secondary coil that couples the signal into the grid circuit of the r-f amplifier tube. The strip on the left contains the oscillator coil on the left end, the mixer input coil in the center and the r-f amplifier plate output coil on the right end.

The spring clip just to the left of the oscillator coil engages the thread of the screw inside the coil form which can be adjusted by the service technician for channel alignment. This adjustment can be made from the front of the tuner as indicated by the holes for channel alignment in Figure 1A. There are no adjustments inside the other coils.

Physically, when the coil assemblies are in place, the turret has the form of a twelve-sided drum which may be rotated by a knob on the turret selector shaft so that, for the desired channel, the appropriate coils are brought into contact with the set of stationary spring contacts which provide the connections to the antenna, RF amplifier, mixer, and oscillator circuits. The turret arrangement affords low stray capacitance and lead inductance because it makes possible very short connections through the contacts from the tuned circuits to the tube sockets.

3-Stage Turret Tuner

In Figure 2 is the circuit diagram of the "turret type" detent tuner manufactured by Standard Coil Products Company Inc. This, along with other models by Stand-Coil, appear in quite a number of different makes of television receivers.

It is a two-tube, 3 stage tuner, using a 7-pin miniature pentode such as the 6AG5, 6BC5 or 6CB6 tube for the r-f amplifier stage, and a 7-pin miniature duo-triode tube, 6J6. One triode section of the 6J6 serves as the mixer stage and the other section serves as the local oscillator stage. The colors noted in the diagram for the leads coming out of the tuner subchassis in Figure 2 are markings for identification when tracing the tuner circuits.

Coils L_1 and L_2 of the input circuit compose the antenna input transformer for one channel, while coils L_3, L_4 and L_5 located between V_1 and V_2 of the diagram are the r-f output, mixer and oscillator coils respectively for that particular channel.

Although the individual coils of each of the 12 sets have different inductances corresponding to the channel frequencies, the coils of each assembly have identical connections on the strips for the respective circuits. Thus, the diagram shows the coil strips of one channel in their proper positions which will be the same for all channels. Only a small portion of the upper and lower channel coil strips for the adjacent channels are shown, since they are out of all circuits during this particular channel selection.

The television carrier signals are coupled from the 300 ohm transmission line to the V_1 grid by the single tuned transformer L_1L_2. The transformer secondary, L_2, is resonated by the tube input and circuit stray capacitances and is similar to the circuit described in the previous lesson. R_8 loads the input circuit for proper bandwidth and antenna matching.

The V_1 bias is obtained from an automatic gain control (agc) bias circuit which is similar to the avc in radio receivers. The filtered agc bias is applied through the isolation resistance R_1 to the bottom end of the grid load.

Coil L_6 in series with the filament circuit is composed of wire heavy enough to carry the filament current. It is made up of a few turns and serves as an r-f filter along with a 1000 $\mu\mu$f ceramic capacitor C_6. A filter like this is usually found in the filament leads of every high frequency stage and prevents unwanted coupling between stages which occurs very readily along any length of wire at these frequencies.

Thus, the combination of L_8C_{13} in the 6J6 filament lead is another heater-circuit r-f filter which again prevents these high frequencies, that couple to the filament through the cathode-to-filament capacitance, from appearing in other circuits of the tuner and receiver. In fact, if one of these ceramic capacitors were to open, the unwanted r-f in the filament leads could produce oscillation, interference, and alignment problems.

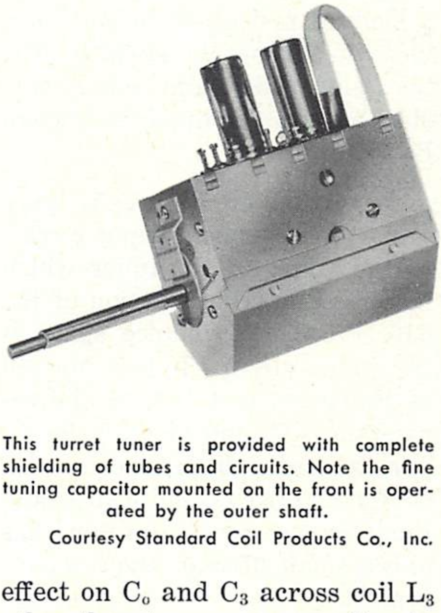
Figure 3A is an equivalent circuit of the input portion of this tuner. C_1 and C_2, which are in parallel, are actually in series with the input capacitance of the r-f stage, C_{in}, and together are part of a parallel resonant circuit involving the inductance L_2 and the distributed capacitance C_d of any one of the 12 coils switched into position.

If C_1 or C_2 became defective, the input circuit would be detuned from the desired resonance resulting in a reduced signal output from the tuner. This is particularly true on the higher channels because L_2 and C_d have relatively low values making the other capacitances in the circuit proportionally more effective.

The tolerances on the twelve coils used in the L_2 position for the various channels are somewhat close because once the trimmer adjustment of C_2 is made in the alignment of the tuner, it remains fixed. Thus, the switching in of the different coils, determines the input circuit resonant frequency.

The bandwidth of each fixed-tuned circuit is at least 6 mc, which is produced by the close coupling between L_1 and L_2, fixed on the coil form, and the 3900 ohm loading resistance R_8 in the tube grid circuit.

Figure 3B is an equivalent circuit of the output portion of the r-f amplifier. Again the circuit is a parallel resonant arrangement. C_3 and the tube interelectrode capacitance C_o are in parallel and together are in series with the 120 $\mu\mu$f ceramic capacitor C_8 to the bottom end of coil L_3. Capacitor C_8 also serves as a B+ r-f filter. Since the capacitance of C_8 is comparatively large, it has little effect on C_o and C_3 across coil L_3 other than to serve as coupling to complete this part of the resonant circuit.



This turret tuner is provided with complete shielding of tubes and circuits. Note the fine tuning capacitor mounted on the front is operated by the outer shaft.

Courtesy Standard Coil Products Co., Inc.

If C_8 opened, the tuner could become unstable to a point of oscillation; the L_3 circuit would be definitely detuned resulting in reduced signal output from the tuner. If C_8 shorted, a zero signal condition would be the result because B+ would be shorted to ground which would probably burn up R_2. Both parts could be replaced upon removal of the turret from the tuner assembly.

The additional capacitance for the final resonant condition to develop the channel signal is again found in the distributed capacitance of each of the coils switched into position. The 10 K resistor R_6 in the plate circuit serves as a loading resistance to help provide the proper bandwidth. The television video and sound carriers are coupled inductively from L_3 to L_4.

A portion of Figure 3C contains the equivalent input circuit of the mixer of the tuner which involves one triode section of the 6J6. Parallel resonance again is the tuned circuit. It is composed of the input coil L_4 and the capacitances C_d and the variable C_4 paralleling C_{in}, both in series with C_9. Capacitor C_9 is quite large and thus, in its series position, has only a small effect on the resonant condition.

The main function of C_9 is to couple the signal and at the same time provide grid leak bias along with the large grid resistance of R_3 and R_4 to ground. R_3 actually serves only as isolation from the main parallel tank for a test point.

If C_9 were to open, there would be no signal in the output of the tuner unless the stray capacitance was sufficient to supply a signal to the mixer grid; and then only a very weak output could result.

The input coupling circuit uses a combination of resistance loading in the primary L_3 and overcoupling of L_3 and L_4 to provide the proper bandwidth.

Attention is called to the fact that trimmer capacitors C_2, C_4 and C_5, which have an alignment variation of from .5 $\mu\mu$f to 3 $\mu\mu$f, have critical effect on the high frequency channels because of the very small distributed capacitance C_d across the few turns of the high channel coils. Actually, they are similar in effect to the trimmers on a radio receiver.

At the lower channel frequencies, 2 through 6, quite a number of turns are involved, in coils L_2, L_3 and L_4, making their distributed capacitances comparatively large, and so the paralleling trimmers have less alignment effect. Thus these particular tuner trimmer aligning adjustments are usually set for optimum tuner output at one of the higher VHF channels such as, channel 9, 10 or 11.

The equivalent circuit for the output of the 6J6 triode section mixer is included in Figure 3C. The oscillator frequency along with all of the sound and video high carrier-frequency components of the r-f original signals and their sums are eliminated by the r-f filter action of C_o-C_{16} in conjunction with the mixer output tuned load.

The output i-f signal actually appears in the series tuned resonant circuit including L_9, C_{14}, C_{in}, and $C_o + C_{16}$. C_{14}, a d-c blocking capacitor used for signal coupling, has no effect on the resonance of this circuit. If it were to open there would be no signal applied to the i-f section. L_9 is aligned to resonate the circuit in the output of this tuner in the 20-30 mc region. Both the video i-f of 25.75 mc and the sound i-f of 21.25 mc appear with their sidebands in the resonant circuit, thus the bandwidth has to be relatively broad.

This bandwidth is accomplished in part by the shunting effect of the 15 K plate resistor R_9 lowering the Q of the circuit. The B+ ceramic filter capacitor C_{17} of 1000 $\mu\mu$f effectively places R_9 in the resonant circuit. The low plate resistance of V_3 parallels R_9 from the grounded cathode which is also the bottom end of C_{in}, through the tube to the top end of L_9 and thus adds to the shunting effect of R_9. This, along with any inherent resistance in the tuned circuit and any particular L/C ratio condition, as mentioned in previous lessons, provides the proper i-f bandwidth of this circuit.

If any of the R, C, or L components in this circuit opened, the signal output in most instances would go to zero since they would interrupt or completely detune the signal. Should the by-pass C_{17} open, the circuit would be unstable and possibly oscillate; if signals were present, the i-f response of the output tuned circuit would probably be too narrow and not pass both sound and video i-f's because R_9 would no longer be referred to a-c ground to load the tuned circuit.

Figure 3D is the equivalent circuit of the Colpitts local oscillator in the tuner. One can see almost immediately why the Colpitts style oscillator is so popular for high frequency applications in the fact that ALL OF THE CAPACITANCES AROUND THE ENTIRE CIRCUIT CAN BE CONVENIENTLY INCORPORATED INTO ONE RESONANT TANK CIRCUIT, AND CHANNEL BAND SWITCHING BY COILS IS SIMPLIFIED, SINCE NO TAP IS REQUIRED FOR THE COILS. C5·C12

In this particular oscillator circuit, the total feedback capacitance is composed of C_5, C_{12}, and C_{pk} plus C_o, which makes up a portion of the tapped capacitance. The 10 $\mu\mu$f capacitor, C_{11} from grid to ground plus the total grid to cathode stray and interelectrode capacity C_{in} represent the other portion of the tapped capacitance for this Colpitts oscillator.

Capacitor C_{10} serves two purposes in that it combines with the 10 K resistance R_5 to provide grid leak bias for the oscillator and secondly, it blocks d-c from the plate circuit of the oscillator.

Since oscillator efficiency drops off at the high frequencies due to reduced L/C ratio and transit-time effects, an alignment adjustment, which effects the oscillator feedback and L/C ratios, is made on the trimmer capacitor C_5 for oscillator peak performance; this is done in conjunction with the adjustment of the r-f and mixer trimmers on one of the high VHF channels mentioned previously.

During the period of time while C_5 is being adjusted, the resonant frequency shifts extensively so that a compensating adjustment of L_5 will have to be made to keep the oscillator at the proper frequency for that desired channel. The proportional change of inductance will maintain the correct i-f difference away from the r-f signal appearing in L_4, so that the mixer output intermediate frequencies remain correct in order to be accepted by the mixer output i-f circuit. For example, when C_5 is reduced then L_5 is increased; this maintains the proper tank frequency and also improves its L/C ratio.

C5-L5

The trimmer capacitor C_5, like most tuner trimmers, is of the machine screw type, such as illustrated in Figure 3E. Should the lock washer turn slightly to a loosened condition, the entire screw-trimmer unit will be loose and the ground return for the capacitor will be poor. This will result in erratic operation of the particular circuit concerned. It can cause, weak intermittent or noisy output from the tuner and, in cases where the circuit is extensively detuned by the condition, may result in no signal output at all.

When this trimmer C_5 is finally fixed on a specific high channel, all the other oscillator coils, when in L_5 position, are adjusted to tune in their respective channels. These adjustments are made through a hole from the front of the tuner as shown in Figure 1A, until each channel is tuned in and set so that the fine tuning control C_{12} provides the proper maximum to minimum fine adjustment effect on the channel.

Returning to Figure 2, the fine or vernier tuning capacitor C_{12} in this tuner, is composed of two stationary metal plates, one of which is a small metal disc mounted on, and insulated from, the metal sub-chassis on which the entire tuner is assembled. The other capacitor plate is a small rectangular metal bracket that is grounded to the front of the metal sub-chassis and mounted so that there is a space between it and the insulated metal disc. Located between these two metal plates is a rotor which consists of a plastic disc of a very high dielectric constant. It has a constantly changing radius so that more or less of the dielectric material appears between the plates as the shaft is rotated.

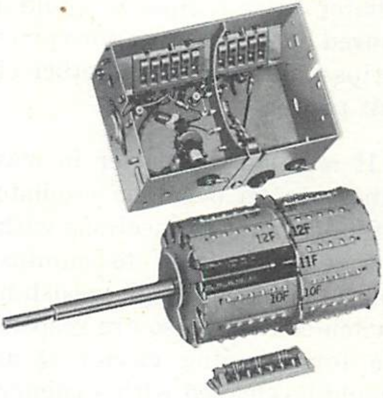
Slight shifting of the tuner oscillator frequency as a result of heat and aging can thereby be compensated for in this customer control fine tuning adjustment. The control produces an average change of only 2 or 3 mc on the lowest channel and about 18 mc on channel 13.

In many cases the fixed capacitor such as the 10 $\mu\mu$f, C_{11}, from the oscillator grid circuit to ground, is a negative temperature coefficient capacitor which maintains the oscillator at a more accurate frequency as the tube and various parts in the circuit become heated. As this capacitor becomes warm, its capacitance reduces somewhat to compensate for other capacitance increases.

The oscillator signal is inductively coupled from its coil L_5 to the mixer input coil L_4 where it appears at the grid of the mixer together with the video and sound carriers of the desired channel. The signal from the oscillator must be relatively stronger than the strongest channel carriers so that the i-f signal amplitude out of the mixer plate circuit is dependent only upon the strength of the channel carriers.

Servicing Pointers

One of the main causes of troubles in electronic circuits is tube failure. Thus, if a television tuner should become defective in its output, such as being weak, intermittent, noisy, or having no output, its tubes should be checked first.



The turret tuner can be easily disassembled with but a few operations. The snap-in coil strip containing the oscillator, mixer and r-f coils for channel 11 is shown removed from the turret. Note the matching spring-contact panel for the turret strips in the upper side of the chassis.

Courtesy Standard Coil Products Co., Inc.

Should the oscillator signal become weakened to an amplitude below the amplitude of the channel carriers, the mixer output i-f signal amplitudes would be weakened proportionally which, in turn, would reduce the sound and picture output of the receiver. Moreover the picture would be distorted.

One of the general causes of a weak oscillator signal would be a weak oscillator tube. Since replacement is simple, it should be the first component checked. Changes in supply voltages to the circuit can also reduce signal output and should be checked if necessary. A reduction in tuned circuit Q, which will reduce the oscillator or r-f signals, could be caused by poor connections on coil strips, tube socket, and other circuit points.

It is a simple matter in many tuners to go over the oscillator, r-f, and mixer connections with a hot soldering iron to eliminate tuner troubles. High resistance switch contacts also are responsible for lowering circuit Q and should be cleaned with a commercial contact cleaner.

Changes in parts values such as the RC grid leak bias components of an oscillator circuit also can reduce the output. In Figure 2, if a change occurs in one of the fixed capacitances of the oscillator tank circuit, the L/C ratio may be reduced when readjusting L_5 to proper resonance. Therefore, the feedback ratio will be altered and so capacitor replacement and realignment would thus be required.

Since some of the fixed capacitances exist in the interelectrode capacitance of the tube itself, the oscillator tube could be the reason for a misalignment and an improper L/C ratio of the oscillator tank and should again be checked first. There are comparatively few physical parts in the oscillator circuit and thus, parts substitution of a suspected capacitor or resistor may sometimes be a very quick and effective means to tuner repair.

Any physical damage to a turret tuner is usually easily repaired since the entire tuner can be disassembled with a few simple operations. If one of the coil strips is broken, poor reception or none at all will be the result on that channel because the strip contact points cannot be held firmly against the circuit panel spring contacts. Easy replacement with a new strip will again provide proper signal coupling and tuner output.

Intermittent signal or no signal output from the tuner on all channels could be the result of the detent roller and spring being out of position or missing. If the detent unit is out of position, the turret will lock in so that the strips will all be off contact. If the detent roller is missing, the turret will rotate freely without any mechanical locking action which makes it difficult for the strips to hold firmly against the spring contacts.

These descriptions of the circuits and mechanics of one of the popular tuners along with the servicing pointers, contain important analysis and technical points which are common to many other commercial tuner arrangements, and should be kept in mind during the remaining descriptions on other makes of tuners.

Cascode Turret Tuner

This cascode television tuner incorporates all of the features already described in this and the previous lesson. Employing the circuit shown in Figure 4, and manufactured by Standard Coil Products Co., is a two tube turret type unit in which V_1V_2 is a type 6BQ7, 9-pin miniature, duo-triode r-f amplifier. V_3 is a type 6J6, 7-pin miniature, duo-triode. One section of V_3 is used as the mixer and the other as the oscillator. Thus, the two tubes incorporate 4 stages.

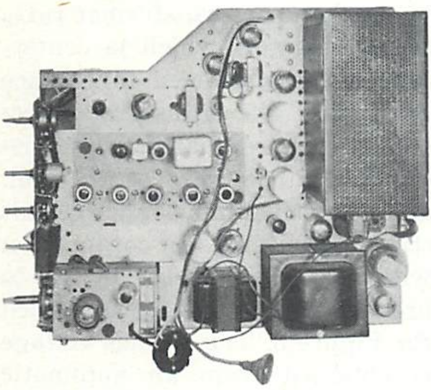
For tuning from channel to channel, the tuning coils L_1, L_2, L_3, L_4, and L_5 of this circuit are again changed by means of the twelve-position turret that carries twelve sets of antenna snap-in coils and twelve sets of r-f, mixer-oscillator snap-in coils identical to the arrangement already described or just 12 sets of snap in coils where all of these coils for one channel are mounted on one form instead of two. Each set of coils is built as an assembly that may be removed easily for repair or replacement. In the Figure, L_1 and L_2 again represents the antenna coil, and L_3, L_4, and L_5 represent the coils for the r-f, mixer, and oscillator.

By means of a 300 ohm transmission line, the signal is coupled from the antenna to the V_1 grid by single tuned transformer L_1L_2, the primary of which is center-tapped and grounded to balance the input. The transformer secondary L_2 is resonated by the distributed capacitance of the coil, and the tube input and circuit stray capacitances in conjunction with C_{13}. It is loaded by R_8 to broaden its response as described for Figure 3. The V_1 bias voltage is obtained from an automatic gain control (agc) circuit and applied through R_9 to the low end of L_2.

Tubes V_1 and V_2 are connccted as a cascode coupled r-f amplifier discussed in the previous lesson. Triode V_1 is neutralized and capacitor C_9, connected from the V_1 plate to the low end of L_2, provides the neutralization.

Tube V_2 is operated as a grounded grid amplifier. The grid of V_2 is effectively at zero voltage with respect to its cathode by applying a positive voltage from the B+ voltage divider R_1, R_2, and R_5. The filter R_3C_1 prevents signal variation in the grid of V_2, thus placing this grid at a-c ground for the grounded-grid amplifier application of the circuit.

Capacitor C_{11}, between the cathode of V_2 and the plate circuit, has a capacitance of 1.5 $\mu\mu$f and adds stability to this tuner in the form of neutralization for the V_2 stage.



A view of the top of a television receiver chassis showing a two-tube television tuner sub-chassis in the front-right corner of the receiver.

Courtesy Philco Corporation

The signal is direct coupled from the plate of V_1 to the cathode of V_2, and the required bandwidth is provided by the cascode amplifier input and output overcoupled and resistance loaded circuits.

The coupling between the V_2 plate and the grid of the mixer section of V_3 is by means of the double tuned transformer L_3L_4. The primary L_3, is tuned by the distributed capacitance of the coil, V_2 output capacitance, the circuit stray capacitance and the capacitance of C_3 to obtain the desired response characteristics. L_4 is tuned by the mixer capacitance plus the circuit stray and distributed capacitances and that of C_6.

Capacitor C_5 isolates the tube grid circuit from the low resistance coil and permits grid leak bias to be developed across R_4 and R_6. The mixer i-f output is applied through the coupling capacitor C_{18} to the grid of the i-f amplifier stage. Connected between the mixer plate and ground, bypass capacitor C_7 provides the easy path to ground for the r-f carrier oscillator and other high frequencies in the mixer output and serves in conjunction with the 6-turn coil L_{10} as a low-pass filter for the i-f's. The fixed coil, L_9 and variable L_{11} have quite a few more turns than L_{10} and serve as the mixer output i-f tuned load, which again includes C_7 and the input capacitance of the i-f stage.

The local oscillator of this tuner is again a Colpitts oscillator and is practically identical to the one described in the circuit of Figure 2, with its equivalent diagram in Figure 3D. The only difference exists in the removal of the oscillator trimmer capacitor, C_5, from Figures 2 and 3D.

Thus, the capacitor C_8 to cathode, along with the fine tuning capacitor to ground or cathode, serve as the physical tapped capacitances across the oscillator coil L_5. The other tank capacitance effects are the same as represented in Figure 3D for the other tuner circuit.

Adjustable from the front panel by an alignment tool, small brass screws are partially inserted into each oscillator coil to provide an adjustment of the oscillator coil inductance so that the oscillator frequency may be corrected for each channel.

L_6C_2 and L_8C_{12} along with C_{15} are filters in the heater circuits of V_1, V_2, and V_3 to keep r-f on the heaters from the other tubes in the receiver.

3-Stage Bandswitch Tuner

Employing pre-tuned wide-band transformers for each VHF channel, the switch type tuner used in a television receiver is shown schematically in Figure 5A. Here, each of the transformers, T_2 to T_{10}, couples the output signal from r-f amplifier V_1 to the grid circuit of the mixer, V_2. Many of the transformer coils are mounted on the wafers of a bandswitch similar to Figure 8.

To show the electric circuit for a particular channel, the connections to transformer T_6 are drawn in the conventional manner in Figure 5B. As indicated here, the transformer primary and secondary are magnetically coupled, but are isolated from the d-c circuits by blocking capacitors C_3 and C_9. The V_1 plate connects to B+ through $R_{2,3}$ which represents the total resistance of resistors R_2 and R_3 of Figure 5A.

The primary and secondary windings of each transformer are self-tuned to parallel resonance by the distributed and tube capacitances to provide high L-to-C ratio and, therefore, higher stage gain. Trimmer capacitor C_4 is shunted across the primary and C_{12} across the secondary of each transformer to permit compensation for differences of tube capacitances when tube replacement is necessary.

The i-f range of this tuner is in the 20 to 30 mc region, thus when switched to channel 2 (54-60 mc), the local oscillator will be operating at approximately 81 mc. If any r-f from an FM station, that is 20 to 26 mc distant above the local oscillator, gets through to the mixer it will beat with the local oscillator frequency to produce an interfering i-f, known as image interference. Therefore, on channel 2, coupling transformer T_2 is triple tuned for better attenuation of the image frequencies in the 88 to 108 mc FM broadcast band. Tuned line $L_5L_6C_{15}$ is inductively coupled to the T_2 primary and secondary and tuned to the correct frequency by adjustable cores in L_5 and L_6. When properly tuned, the coupling circuit provides the response of the required bandwidth with comparatively steep sides.

The tubes employed are a triode connected pentode r-f amplifier, V_1, and a double triode type 12AT7, one section of which is used as the mixer V_2 and the other as the high frequency oscillator V_3. With its suppressor and screen grids connected to the plate, V_1 operates as a triode in a grounded grid r-f amplifier circuit. The purpose of this arrangement is threefold: it improves the signal-to-noise ratio, removes the necessity of neutralizing the amplifier stage and provides for a low input impedance. Although the noise output of a pentode is very high, when the tube is operated as a pentode, by connecting the screen and suppressor grids to the plate, it exhibits the noise characteristics of a triode while retaining a high transconductance.

To provide a practically constant impedance to the antenna transmission line at all frequencies, the line is connected through transformer T_1 into the low impedance of V_1. This arrangement permits optimum transfer of signal from antenna to r-f amplifier for all 12 channels and matches the receiver to the transmission line. As shown, the T_1 primary is balanced to ground, thereby providing cancellation of noise energy picked up by the transmission line. To prevent noise being capacitively coupled from primary to secondary, an electrostatic shield, shown as a dashed line, is incorporated between the windings of this transformer.

R_1 serves as the V_1 cathode bias resistor and is bypassed by capacitor C_2. Coil L_2 is in series with V_1 to prevent the cathode circuit impedance from changing by the shunting effect of C_2. When the station selector switch is set for any of the seven higher VHF channels, coil L_3 is connected in parallel with L_2 to reduce the total inductance in the cathode circuit and thus maintain the same impedance at the higher frequencies. Tuned to series resonance by the circuit input capacitance, peaking coil L_1 is employed to minimize the loss of signal strength at the higher television frequencies. C_1 is a d-c blocking capacitor that prevents the bias from being shorted to ground through the low d-c resistance of L_1 and the T_1 secondary.

From the V_1 plate, signal variations are coupled through capacitor C_3 to the primary of the selected transformer. Three of the r-f transformers, T_8, T_9, and T_{10}, cover the upper 6 channels, each being designed with sufficiently broad bandwidth to accept two channels. From the secondary of the selected transformer, the signal is coupled through C_9 to the grid of mixer tube V_2.

A large amplitude signal from the local oscillator is coupled through C_{10} to the V_2 grid circuit so that grid leak bias is developed across R_6. In the V_2 plate circuit, the upper portion of T_{11} forms the primary of the first i-f transformer and the lower portion, the secondary, with the center tap effectively grounded for the i-f frequency through capacitor C_{14}. Resistor R_7 is connected across the T_{11} primary to provide the necessary bandwidth for the i-f response.

The V_3 circuit operates as a modified Colpitts oscillator like that described in the previous lesson, with the tapped capacitance formed by capacitor C_6 and the plate-to-cathode capacitance C_p, indicated by dotted lines. The tube plate is grounded for r-f by capacitor C_5. Choke L_4 maintains the cathode above ground for r-f voltages while providing a path to ground for the d-c plate current.

The oscillator section of the station selector switch is ganged to the r-f amplifier and mixer sections and operates to provide a different oscillator coil for each of the six channels, 2 through 7. Coil L_{13} is used for channels 8 and 9, L_{14} for channels 10 and 11, and L_{15} for channels 12 and 13.

Variable capacitor C_8 is the fine tuning control and serves to tune the oscillator to the correct frequency for the selected channel. In the case of channels 8 to 13, C_8 tunes the oscillator for one or the other of the two channels covered by each coil.

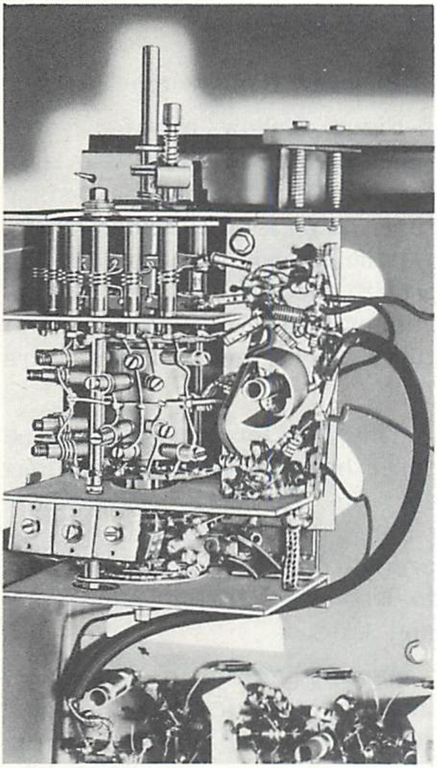
Cascode Bandswitch Tuner

Figure 6 shows a wafer-switch tuner used in a Zenith television receiver. It is a two-tube, 4-stage tuner using a 6BK7A, duo-triode, for the cascode r-f amplifier, and a 6U8, triode-pentode, for the oscillator and mixer stages. Both tubes are of the 9-pin miniature type.

This 3-wafer bandswitch type tuner has 12 switching positions for the 12 VHF channels, 2 through 13. The 3 wafer sections are noted in Figure 6 from right to left as Oscillator, R-F Plate, and Antenna.

As can be seen in Figure 8A, most of the inductances and other components are mounted on the tuner wafer sections. The oscillator wafer assembly, physically at the front of the tuner unit, is composed of series inductances, which contain adjustable brass screw type cores that are accessible from the outside with the use of an alignment wrench for individual channel alignment.

The mixer or r-f plate section which is the center wafer assembly, and the antenna section which is the rear wafer assembly are each composed of fixed series inductances that may be adjusted for peak operation on channel, by a critical pushing or bending of the individual coils. This is usually done only in factory alignment, unless a tuner has been physically mistreated, or a wafer assembly has been replaced.



The under chassis view of a type bandswitch VHF tuner employing brass core tuning adjustment for the coils. Note the tuner output is applied through a piece of coaxial cable to the i-f amplifier section.

Courtesy Motorola, Inc.

The coil arrangement in this type of switch tuning is referred to as an incremental tuning method; since, as the tuner is switched, for example, to lower channel frequencies, the inductances around each wafer assembly are added in series to lower the resonant frequency of the circuits.

The antenna input of the tuner in the circuit of Figure 6 is balanced to ground, and has a 300 ohm impedance in transformer T_1. The signal is applied through an i-f trap assembly in the 40 mc to 50 mc range. This prevents r-f signals in this frequency range, such as police communication etc., from getting into the 40 mc range i-f amplifiers of the receiver and interfering with the sound and picture on all channels.

The purpose of the 470 K resistors R_1 and R_2 in the i-f trap assembly is to allow any static charge, that could build up on the antenna, to leak off to ground through T_1 primary.

The switching arrangement in the diagram of Figure 6 is shown in the channel 13 position. The secondary of the input transformer is tapped for the higher channels, 7 through 13 (174 mc – 216 mc). In any of these higher channel switch positions, the ungrounded end of T_1 secondary, which connects to point 6 of S3R, does not connect to any circuit.

Thus, with the switching arrangement as indicated for channel 13, the channel signals are applied from the tap on the secondary of T_1 to point 12 of the antenna wafer assembly, S3F. From there the channel signals go through the switch contacts to point 13 and then through the L_8 channel 13 inductance, to the grid pin 7.

The equivalent circuit of this input section, shown in Figure 7A, is a resonant arrangement similar to that previously described in other tuner circuits. The lead inductance plus L_8 in series with C_{in}, is series resonant at the desired channel r-f, and selects the signals from the secondary of T_1.

Since maximum signal voltage exists across the individual units of L and C of a series resonant circuit, the maximum signal condition which exists across C_{in} at resonance, conveniently appears at the grid of VIA. The 15 K resistor R_3, with a signal return to ground through C_{10}, lowers the Q of this input tuned circuit to provide for a bandwidth that will pass both video and sound r-f signals in the proper passband.

When the bandswitch in Figure 6 is turned to lower channels an increased inductance is added in series with that used for channel 13. For example, when the tuner is switched to channel 9, S3F will make contact from point 8 to point 13. The channel r-f will again be applied from the tapped secondary to point 12 and then through the series added inductances from point 12 to point 8. From there the signal path goes to point 13 and through L_8 to the grid of V1A.

The high channel inductances in this antenna circuit are added in series only down through channel 7 (174 mc – 180 mc). Thus if any of the inductances should open between points 6 and 12 it would not effect low VHF channel reception. Also, if an inductance opened on a junction between points 7 and 8 of S3F, only channels 7 and 8 would be effected since the higher channel reception uses less inductance in the switching arrangement.

On the channel 6 (82 mc – 88 mc) position, S3F of the antenna switch assembly makes contact from points 5 to 13, thus removing any contact with the tap on T_1 secondary or the high VHF channel coils as indicated in Figure 6. At the same time, S3R makes contact from points 6 to 7 and provides an open at all other points which places the entire secondary of T_1 into the input circuit.

The path for the channel 6 r-f signals will be from the T_1 transformer secondary to S3R points 6 to 7. From there the r-f signals are applied through L_4, since point 13 will be open, then to the S3F point 5, and thus to point 13, as mentioned in the preceding paragraph, and through L_8 to the grid of V1A. The resonant input circuit now will be the lead inductance plus L_4 and L_8 in series with the input capacitance of the stage.

When the channel selector is rotated around to position 2, switch S3F will make contact from point 1 to point 13, and S3R continues to join points 6 and 7, while the others remain open. Thus, the r-f signals of channel 2 will go from T_1 through S3R points 6 and 7, then through L_4, L_5, L_6, L_7, and L_3 to common point 1 of S3R which is now open and then to point 1 of S3F. From there the signal path to point 13 and through L_8 to V1A grid again completes the series inductance circuit for resonance with the input capacity of the V1A stage.

If channel 4 is desired, S3F will make contact from points 3 to 13 and the channel signals will go through S3R points 6 and 7 and then through L_4, L_5 and L_6 to point 3 of S3F, from which the signal again continues to point 13 and through L_8 to the V1A Grid circuit.

An open connection in the inductance between points 2 and 3 of S3F would effect reception of the lower 2 channels since, again, less and less inductance is used for the upper channels.

Stages V1A and V1B are incorporated into a typical cascode r-f amplifier as described in the previous cascode circuits. C_9 from V1A plate to the T_1 secondary, is a neutralizing capacitor to reduce displacement current, and grid to plate capacitance effects on the input circuit.

Since the gain of the stage is very low, an open C_9 would only reduce signal and increase noise output in most cases. If it shorted, it would place a positive voltage through secondary T_1 onto the input grid pin 7 to saturate the tube and cause zero signal output. This might possibly damage the duo-triode tube and most likely burn out the V1B 1500 ohm plate resistor R_6, because the V1B cathode would be reduced from a positive potential of 110 volts to a low potential leaving the corresponding grid with a relatively high plus potential.

The r-f plate or mixer wafer assembly between V1B and V2A of Figure 6, also uses the series inductance switching method for tuning the circuit to the desired channels. As shown for the channel 13 position, S2F connects point 1 to point 13. Thus shorting all of the inductances in the wafer assembly, including S2R, that appear in the tuned circuit for any of the lower channels.

The equivalent tuned circuit that exists between V1B and V2A for channel 13 is shown in Figure 7B. The signal output of the cascode amplifier V1B is applied into a resonant circuit comprised of all lead inductances plus L_{16} in series with the capacitances, C_{in} of V2A, and, by common ground return, with $C_o + C_{11}$ of the V1B stage. Again, at resonance the signal voltage will be maximum across C_{in} of the mixer stage for application to the grid. R_6 effectively lowers the Q of the circuit for a proper bandwidth. C_{13} and C_{14} are comparatively large and thus pass all the r-f signals. C_{13} therefore, effectively places the one end of R_6 at ground potential and C_{14} serves as a coupling capacitor. The small inductance between points 12 and 13 is in series with R_6 for channel 13 only and provides a peaking action at this high VHF channel for improved response.

When the tuner is switched to channel 9, S2F will connect point 9 to 1. The closed resonant circuit is now inclusive of L_{16} to point 1, from point 1 to point 9, then through the added series inductances from point 9 to point 13, from there through C_{in} and the common ground return to $C_o + C_{11}$, and then back to L_{16}. Again a maximum signal voltage will appear across C_{in} at resonance for applying the channel signals to the grid of the mixer.

On channel 2 position in Figure 6, S2F switch is at point 2 and thus does not make contact between any points, while S2R makes contact only from points 1 to 2 which are always shorted. This places all of the inductances of the entire r-f plate assembly in series for a low resonant frequency, as neither S2F or S2R short out any inductances in this case.

The actual signal path includes L_{16} to S2R points 1 and 2, then through L_{13}, L_{12}, L_{11} and L_{10} to point 6; from there through L_{26} and an opening, or eyelet, in the wafer to the front side of the wafer and L_{14}; and then through all of the series inductances from point 8 to 13 of S2F which connects to the grid circuit of the mixer.

Attention is called to the fact that all of the inductances in this r-f plate or mixer wafer assembly are added in series for channel 2 except number 7 which was left out for purposes of better tuning, involving the channel 6 coils. Thus, an open connection in one of the coils, except for channel 7 coil, will affect reception on all channels that require added inductances beyond that point.

The oscillator signal of the tuner is applied into the mixer grid circuit through capacitor, C_{15} from the plate of the V2B triode. The oscillator is of a series Colpitts type. Its equivalent circuit, when switched to channel 13 is shown in Figure 7C. Switch S1F of the oscillator wafer assembly makes contact from points 13 to 2, thus shunting all of the inductances on the wafer. This places only L_{22}, L_{23} and any lead inductance into the circuit for the required high oscillator frequency.

In most of the previous Colpitts type oscillators described, the oscillator d-c plate current did not go through the inductance and thus, was referred to as shunt fed. However, in this circuit, the d-c for the oscillator tube goes through that portion of the inductance used in the tank circuit, for a series-fed arrangement.

When the tuner is switched to channel 9, S1F makes contact from point 9 to point 2, and thus adds the inductances between points 9 and 13 of the wafer assembly into the tank circuit. Notice that the tank circuit continues to have a portion of its total capacitance tapped by $C_{gk} + C_{17}$, and C_{pk}. This holds true regardless of which channel is selected.

A portion of the inductance arrangements of the oscillator and antenna wafer assemblies are noted in Figure 6 as being stamped inductances. A metallic surface is actually imprinted in the form of an inductance onto the wafer surface for production convenience, while the other inductances are the usual coils. A few other tuners have more complete printed circuit arrangements, but their circuits and mechanical applications are comparable to the average conditions described here.

The main function of switch S1R of the wafer assembly is to insert C_{19} into the oscillator tank circuit from channels 2 through 6 for convenient tuning to the low VHF channels. In the oscillator switching assembly also, any defect in the wafer circuit will affect those channels requiring any added components beyond the interruption point.

The mixer output is in the 40 mc range with the sound i-f at 41.25 mc and the video i-f, 45.75 mc. These intermediate frequencies appear in the converter plate coil L_{25} which couples into an intercarrier i-f system.

Coil L_{24}, together with C_{16}, in the screen grid circuit of the mixer, series tunes the screen circuit to ground. This series resonant trap condition prevents any signals in a relatively broad-tuned range from appearing on the screen grid and causing degeneration of the mixer input signals. The coil is physically bent to adjust the high-channel range for a good passband at the i-f output from those channels. The mixer bias is developed as usual by the signals applied to the grid, producing grid-leak bias in the discharge action of the coupling capacitors through the 100 K, R_7.

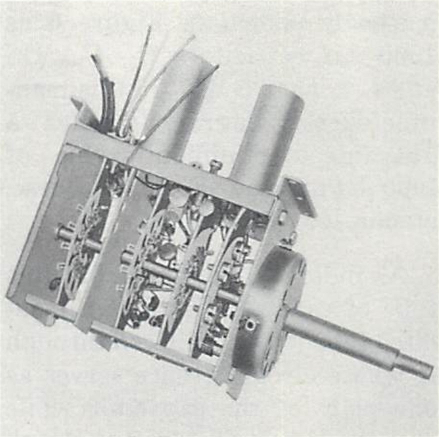
Figures 8A and 8B comprise an exploded view of the Zenith cascode bandswitch tuner. Should any of the wafer assemblies break or become otherwise defective, the entire assembly can be replaced. Occasional cleansing of the switch contacts is necessary when the tuner becomes noisy or intermittent.

The contacting inner sections of the three wafer assemblies forming the switches are mounted on small pieces of insulated material. Each has a centered rectangular hole through which the rectangular shaft is placed. After removal, before the tuner shaft is inserted, these contacting sections must be in alignment one behind the other and all rotated to the same channel contact points.

The detent arrangement in a bandswitch tuner incorporates a ball bearing in a detent assembly, indicated in Figure 8B. Under spring tension, it is held firmly against the back side of the front plate and, as this assembly rotates with the selector shaft, the bearing slips into one of the 12 holes in the plate to hold the shaft and switches at a particular point of rotation for one of the channels.

If the detent assembly is broken or the bearing is lost, the shaft will rotate freely and the channel contact points of the wafer switches will be difficult to engage. Should the detent assembly be twisted out of position, the band switch will lock in between contact points and no signal will be received unless the switch is set somewhere between the incorrect lockin points.

The fine tuning assembly shown in Figure 8B is an eccentric fibre disc mounted on a short hollow shaft that fits over the main channel selector shaft. As the disc is rotated, it changes the distance between two stator strips held against it by spring tension. They are electrically connected to the oscillator coil from the top of the assembly by two leads not shown and thus, as the distance between them is changed, the capacitance



This incremental bandswitch VHF tuner uses a 6BC5 for the r-f stage and a 6J6 for the oscillator-mixer stages. Almost all of the inductances are mounted on the wafer assemblies. The oscillator tuned circuits are accessible through holes at the front of this subchassis for channel alignment.

Courtesy Admiral Corporation

changes and shifts the oscillator frequency.

Figure 9A illustrates a front view of the tuner. Notice the 12 holes for the application of the alignment wrench to the oscillator coil adjustments for channels 2 through 13.

The four "feed-thru" capacitors noted in the illustration are schematically shown in Figure 6 as 1000 $\mu\mu$f capacitors C_6, C_{10}, C_{13} and C_{16}. The "GMV" in this manufacturer's diagram denotes a guaranteed minimum value of 1000 $\mu\mu$f and the "F. T." of course, stands for "feed-thru".

As indicated in Figure 9B, this type of capacitor is like an insulated tube with a solid rod through it whose circumference serves as one plate of the capacitor while an outside metallic coating which is grounded to the chassis, serves as the other plate of the capacitor. The insulating material used is usually a type of ceramic.

In this tuner, these feed-thru capacitors provide connection points for leads from the main television chassis, while the feed-thru of C_{16} serves as a test point.

CONTINUOUS TUNERS

One of the basic methods of continuous tuning involves varying the inductances of coils in tuned circuits by shorting out turns of the coils with mechanically ganged sliding contacts.

Inductuner

Developed by the Mallory Co. for television receivers, a unit called the "inductuner" employs continuously variable inductance tuning. This is accomplished by a variable inductor with sufficient range to tune continuously over the frequency band of 44 mc to 216 mc, thereby including all 12 VHF television channels.

One form of Inductuner, a portion of which is illustrated in Figure 10, employs three such coils, all three being mounted on a single ceramic shaft and tunable continuously for nine turns of the shaft over an inductance range of from .02 to 1.0 microhenry. A sliding contact moves along each coil shorting out turns so as to change the circuit resonant frequency to the proper operating range for the desired channel.

The schematic diagram of a television receiver input section that employs this type of tuner is shown in Figure 11 where the three ganged sections of the inductuner are enclosed by dashed lines. Like most tuners, the unit is constructed on a separate subchassis and contains three tubes: a duo-triode type 6J6 V_1, the sections of which are operated in parallel as a grounded grid ampli-

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fier; a pentode type 6AK5 mixer V_2, and another 6J6, one section of which is used as the oscillator V_3 and the other section is not used.

The r-f signal is fed into the V_1 cathode circuit which is designed to match the impedance of the 72 ohm co-axial transmission line. The r-f amplifier is coupled to the mixer grid through a double tuned circuit that employs two sections of the inductuner. Coils L_1, L_{2A}, L_{2B}, and L_3 are tuned by the shunting capacitances due to the V_1 output capacitance, the V_2 input capacitance and the coupling capacitors C_5, C_6, and C_7. Coils L_1 and L_3 provide the minimum inductance for the high frequency end of the television band.

D-C blocking capacitors C_4 and C_8 are employed to permit isolating the inductuner from the V_1 d-c plate voltage and to permit the use of grid leak bias on V_2 while shunting L_3 and L_{2B} with a comparatively small resistance at R_4. Resistors R_2, R_3, R_4, and R_5 load the tuned circuits to provide the desired bandwidth. For proper adjustment of alignment, capacitors C_5 and C_6 are variable.

The oscillator is a Colpitts circuit and uses one-half of a 6J6, V_3. The oscillation frequency is determined by the resonant frequency of the tank circuit C_{11}, L_4, L_5, C_{gp}, tapped capacitance C_{pk} plus C_{gk} and L_{2C}, which is the third section of the inductuner. Coil L_5 provides the minimum inductance in series with the inductuner at the high end of the television band while L_4 and C_{11} provide for the proper oscillator tracking. Oscillator grid leak bias is developed by C_{12} and R_9 and the oscillator signal is coupled to the mixer grid through C_{13}. To prevent r-f on the tube heaters from reaching other tubes in the receiver, the heaters as usual, are bypassed by C_2, C_9, and C_{15}. The i-f output from the mixer is applied to the i-f amplifier for further amplification.

Since this unit is able to tune to all frequencies between 44 mc and 216 mc, it includes the FM band from 88 to 108 mc. Thus, in the dual channel type of receivers where this tuner was used, the FM band was also indicated on the tuning dial and any FM stations in the particular locality where the receiver was operating could be received.

Mechanically, there are four sliding contacts for each inductance. They are indicated in the schematic of Figure 11 with various letters that correspond to the letters denoting these points in the illustration of Figure 10.

For example, the four contact points for L_{2A} in Figure 10 are points R_R, V_R, X_R and C_R. Point R_R rides against the circular end disc that continually ties one end of L_{2A}, which is soldered to the fixed disc, to ground. Point V_R, the top of the metal slider, rides against the heavy wire of the coil and, as the shaft is rotated, follows along the wire coil from one end to the other, shorting out more or less of the coil to point X_R.

Point X_R is actually a grooved metal plate extending under the full length of the coil and serves as the grounding track along which the slider rides back and forth. The high side of this coil, L_{2A}, is at the right at point C_R with a similar contact arrangement as at the opposite end of the coil. As the slider of this coil moves along the coil to the right, more and more of the coil is shorted out and L_{2A} inductance decreases.

The other two coil assemblies, L_{2B} and L_{2C} are mechanically identical except that the coils are wound in the opposite direction so that any unshorted portion, or remaining inductance, is at the left end of the coils. Coil L_{2A} was reversed to provide for a better physical arrangement in the r-f amplifier circuit to maintain short leads, etc. Since L_{2C}, is part of the ultraudion oscillator tank circuit, the leads from both ends of the coil remain ungrounded to conform to the oscillator circuit in Figure 11.

Occasionally, when this tuner becomes noisy or intermittent, it is the result of one or more of the 12 total moving contact points becoming dirty. A general application of contact cleaner to the three coil assemblies usually remedies the difficulty very quickly.

The metal disc assembly toward the front of the tuner, as shown in Figure 10, is a rugged mechanical stop which prevents the tuning shaft from being rotated beyond a point that would force the three coil sliders off the ends of the coils. The assembly is composed of a number of small metal discs with staggered metal tabs that butt one against the other as the shaft rotates, thereby piling up to a stopping point against the fixed metal disc on each end of the assembly. This allows a total of nine revolutions of shaft rotation and keeps the sliders within the ends of the coils.

Spiral Inductuner

A variation in the Mallory Inductuner places three or four sets of ganged coils laid in ceramic forms into a concentric spiral arrangement as shown for one section of the ganged assembly in the illustration of Figure 12. The tuning shaft assembly and mechanical stop arrangement is similar in nature to that illustrated in Figure 10 but the inductance is varied from maximum to minimum in 6 revolutions of shaft rotation and tunes from 52 mc to 216 mc, which again includes the FM band.

Each coil is fixed in place and a movable wiper arm, the main section of which is attached to the ceramic tuning shaft, works as a sliding, shorting contact at point V_R, Figure 12. The entire arm touches the coil of heavy wire only at point V_R under the spring tension of the small section of the wiper arm. Point R_R serves as a continual return to point X, and is in the form of a sliding contact held firmly against the metal shoulder of the wiper arm by the spring tension of the metal strip between points R_R and X.

This spiral tuning assembly is used in an electric arrangement similar to that of Figure 11 and also in a two tube arrangement such as in that of Figure 13, where the 7-pin miniature pentode 6CB6 is the r-f amplifier and the 9 pin miniature duo-triode 12AT7 is the oscillator-mixer.

The r-f signal is applied across a 72 ohm input in this circuit and then through C_1 of the high-pass filter composed of C_1, L_2, and C_3, to the first spiral tuned inductance, L_3. The high pass filter prevents any interfering frequencies below 50 mc from entering the receiver.

Tunable L_3, together with the end inductance, L_4 and the capacitances of $C_4 + C_{in}$, and C_2 form a resonant circuit at the desired channel frequency thus providing maximum signal across $C_4 + C_I$ at the grid of the r-f amplifier. The circuit tunes broadly to accept an entire channel because of the loading effect of the low input impedance of 72 ohms.

The second section of the assembly, L_6, tunes the circuit between the r-f plate of the 6CB6 and the mixer grid of the 12AT7 to parallel resonance with L_5 and all shunting capacitances present, which includes C_9, output and input capacitances of the two stages, and the distributed capacitance of the coils.

The local oscillator is a Colpitts circuit with the tapped capacitance existing in the form of C_{12} plus the plate capacitance to the grounded cathode and C_{16} plus the grid capacitance to the grounded cathode.

Coil L_9 paralleling L_{10} provides for correct tracking between the oscillator and the r-f signals on the low end of the dial, thus maintaining the i-f difference for the entire tuning range. It has an effect identical to a padder capacitor or cut rotor in a radio receiver.

Coil L_7, in series with the oscillator coupling C_{11} and the input capacitance of the mixer, provides a peaking arrangement for compensation on the high frequency end of the VHF band.

The frequency range of the i-f from the plate of the 12AT7 mixer is in the 20 to 30 mc region.

The shield cover fitting over the tuning section of this tuner is easily removable for purposes of cleaning and repair, by untwisting three clips on one side of the cover.

Another type of variable inductance tuning, uses a printed circuit method in circular printed metallic strips on wafer surfaces. A set of ganged sliding contacts short out more or less of the printed inductances in each of the stages of the tuner to select the desired channel.

Variable Capacitance Tuner

One type of variable capacitance type television tuner was manufactured by General Instrument Corporation. Electrically, the ganged capacitor sections perform in the same manner as the ganged capacitance sections in a radio receiver.

One circuit arrangement for the capacitance tuning unit is shown in Figure 15 which is a typical 3-stage circuit involving the usual pentode r-f, triode oscillator and triode mixer described in previous circuits.

As can be seen in the picture of Figure 14A, some of the capacitive tuning gangs have a split plate section arrangement for each stage. Approximately 180° of the tuning shaft holds capacitor plates that are small in area or few in number while the opposite 180° of the shaft holds capacitor plates that are large in area and have more capacitive effect for tuning in the low channel range. The tuning shaft is rotatable on a 360° continuous arrangement.

All of the small capacitor plate sections are electrically switched into the high channel circuits during the tuning of the high VHF channels from 7 to 13, while all the large capacitor plate sections are switched into the low-channel circuits for tuning channels 2 to 6.

Other ganged capacitor tuners have only one grouping of plates and use fixed capacitors switched in series with the stators, along with a switching change in operating inductances, to raise the resonant frequency of the circuits for the high VHF channels.

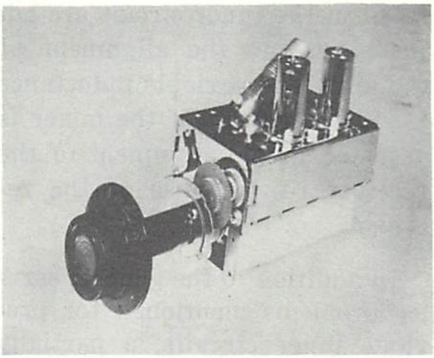
In either case an automatic 2-position switching arrangement pictured under the coils in the unit in Figure 14B accomplishes the circuit change by being mechanically coupled to the shaft rotation, so that a change in bands is initiated each time the rotor is tuned through a high to low band division.

The "HI-LO" switching arrangement of S1A in the input circuit of Figure 15, provides the equivalent condition shown in Figure 16A during high-band channel tuning. The circuit is parallel resonant tuned, which also includes the input capacity of stage V1. The 100 $\mu\mu$f coupling capacitor C_7, isolates or blocks the grid circuit agc voltage and prevents it from being shorted to ground through the extremely small d-c resistance in the few turns of L_1 and T_1. Incidentally, transformer T_1 is equipped with a grounded electrostatic shield to reduce capacitive coupling of noise from the antenna circuit.

The ganged switching arrangement in S2 and S3, as indicated in Figure 15, places C_{13} and C_{16} in series with the tuning gang for high VHF band operation, along with the proper set of inductances, L_2-L_3, and the mutual impedance L_m, which is a length of wire to ground. Again the overall circuit is resonant with the output and input capacitances of the 2 stages.

The ganged switching arrangement in S-4 and S-5 is in a typical Colpitts oscillator circuit and, in the high-band position as shown in Figure 15, switches the high-band coil, L_8, into the tuned circuit as it shorts out the low-band coil, L_7. It also places C_{21} in series with the tuned circuit for the over-all high-channel VHF coverage. Capacitor C_{17} couples the oscillator signal to the grid pin 5 of the mixer.

The equivalent input circuit for low VHF channel coverage is shown in Figure 16B. L_1 is now effectively out of the circuit being placed in series with R_1. The full inductance of T_1 is now used in the parallel resonant circuit which is loaded by R_1, in series with the now ineffective L_1 to ground, for the proper channel passband.



This continuous tuner is of the concentric spiral type using tubes such as a 6CB6 pentode r-f and a 12AT7 duo-triode, mixer-oscillator. A number of continuous tuners have a gear reduction arrangement similar to that in this tuning shaft assembly.

Courtesy Allen B. DuMont Labs., Inc.

Because of the somewhat reduced L/C ratio during high-band operation, the 10 K resistance, R_2, in series with C_{10} to ground serves as sufficient loading for the proper pass-band in Figure 16A.

On the low-band channels, switches S2 — S3 place the coupling network of C_2, L_4, L_6, R_4, L_5 and C_3 into the circuit. R_4 adds

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resistance to the tuned circuit to broaden the passband. In both the high and low band circuits, an inductance L_m provides a common, or mutual, load for coupling the signals from the V_1 plate circuit to the V2A grid circuit. The .68 $\mu\mu$f capacitance C_{26} between V_1 and V2A, acts as additional coupling at the high channels.

The ceramic trimmer capacitors C_8, C_9, C_{14}, C_{19}, and C_{22}, indicated in the tuner circuit are adjusted during the alignment of the unit. The variable inductance L_{10} in the output of the mixer is adjusted in the alignment of the receiver i-f response of the receiver.

In addition to the general service problems mentioned for previous tuner circuits, a partially shorted capacitor section in the tuning gang may produce noisy or intermittent reception or no reception at all for various channels depending how badly the section is shorting. With the few capacitor plates involved for each section, it is a relatively simple matter to clean and adjust them. If the 2-position band switch should become dirty, similar troubles will be encountered until a contact cleaning fluid is used. Reception of one band of channels and none on the other, might be the result of one of the band-coil circuits being open.

In many cases where this type tuner was used, a mechanical detent plate was added to the shaft at the front of the tuner and aligned for a holding action on a ball bearing detent when the ganged rotor was turned to the proper point. This provided a positive switch action for channel selection although tuning was accomplished by means of variable capacitance.

Permeability Tuner

A system which varies the inductances of the tuned circuits by a method of moving powdered iron cores in and out of fixed coils is another principle of continuous tuning used in several makes of tuners. This form of tuning is referred to as permeability tuning, and is that which has been used in radio receivers for quite a number of years.

One type of permeability tuner unit is illustrated in Figure 17. The tuning gang is comprised of a treadle bar on which is mounted three sets of cores for tuning the oscillator, mixer, and r-f circuits.

The treadle bar can be moved up or down by the cam arrangement of the tuning dial assembly and thus moves all the cores in or out of the fixed coils mounted in the unit. This changes their inductance for selection of the various channels.

A high-low band switching arrangement in the form of a ganged slider switch for application similar to the band switching principle in the tuner described previously, is actuated by an offset portion from the side of the front and back cams mounted on the tuner shaft. Each set of cores is associated with a high-band coil and a low-band coil, thus only three of the six cores are performing a tuning function at any one time depending on the VHF channel band being tuned.

The 3-stage permeability tuner circuit incorporates a 6AG5 r-f amplifier, and either the 7-pin miniature 6J6 or the 9-pin miniature 12AT7 for the mixer-oscillator stages. The cascode permeability tuner arrangement uses the 9-pin miniature 6BZ7 r-f amplifier and the 9-pin miniature 6U8 mixer-oscillator.

In the four-tube permeability type tuner which was manufactured by Stromberg Carlson Co., a high-low band switching arrangement places the 6AG5 and 6J6 circuits into operation for high-band VHF channel selection, and a 6BH6 and a 6J6 are switched into operation for low-band channel selection. The ganged cores mounted on the treadle bars were made of powdered iron.

Figure 18 is a circuit diagram of the 2-tube permeability tuner using a 6AG5 and a 12AT7 in the 3-stage arrangement. Notice that the band switch is shown in the high-band position which places the high-band L_1 portion of the antenna transformer into the circuit.

The primary circuits of the input transformers are connected in series with C_1-L_1 fixed and broad tuned to accept all the low-band channels and C_2-L_2 fixed and broad tuned to accept all the low-band channels. The high-band channel frequencies pass through C_2 of the low-band section without any hindrance to appear in the high band resonant circuit, while the low-band channel frequencies pass through the primary coil of the high-band circuit without being hindered to appear in the low-band resonant circuit.

The broad-tuned condition is achieved on the high-band channels as a result of a low L/C ratio, while for the low band, an extra swamping resistance in R_1 of 680 ohms provides the broad acceptance.

The functioning permeability tuned inductances for high-band operation are L_4 and L_6 in the r-f output and converter input circuits, and L_8 in the oscillator circuit.

L_4, C_6 plus high band adjustment C_7, and the output capacitance of V_1 tune the signal from the inductive load L_3 and apply it through the coupling capacitor C_9 to the mixer grid tuned circuit of L_6, C_{13}, plus adjustable C_{14}, and the input capacitance of V_{2A}.

The voltage on the screen grid of the V1 r-f amplifier stage is reduced from B+ by a 1000 ohm resistor R_6 and maintained at a steady level by the capacitor C_5 from pin 6 to ground. Should this 1000 $\mu\mu$f capacitor open, a degenerative condition will occur in the stage causing a reduced output of the signal from the plate circuit. In cases where the received signal is already weak, the output of the receiver may then be too weak for a picture.

Of course, if the capacitor should short, the output of the tuner will go to zero since B+ will be shorted to ground through R_6. In all probability in this case R_6 would burn up and the screen voltage would still be zero. A visual inspection of the tuner is often effective in locating burned parts such as this. A complete repair would now require replacement of both the resistor and capacitor.

A shorted B supply and a consequent burned open resistance sometimes is caused by a defective tube with a short between the screen and suppressor grids or other internal short to the low side of the B supply. Replacement of the defective tube would, of course, not put the tuner into operation until the resistor is also replaced.

The oscillator is a Colpitts with C_{22} in series with C_{23} plus the output capacitance of V2B to ground for one side of the tapped capacitance, and C_{26} in series with C_{gk} to ground for the other portion of the tapped capacitance across the tuned inductance L_8. The oscillator signal is coupled from the plate of the oscillator through the 1 $\mu\mu$f C_{20} to the grid of the converter or mixer.

The output load of the mixer, although not shown, is applied into the usual tuned circuit leading into the i-f stage.

An added consideration in this type of tuner is the screw adjustment of the cores on the treadle bar. Should the thread loosen and the vertical placement of a core be changed, the tuned circuit of that particular core will not track with the other circuits and will cause broad, inaccurate tuning; and weak or no reception. The quick remedy involves obtaining the manufacturers specifications on the dimension in inches of core adjustment into the coil at a certain position of the tuning dial, then sealing this thread adjustment with cement on the treadle bar, and following through with the specific circuit alignment procedure if necessary.

This lesson has described the common methods employed for VHF television tuners involving their circuits and also their mechanical arrangements. The servicing points described hold true for all tuners of similar circuit and mechanical categories.

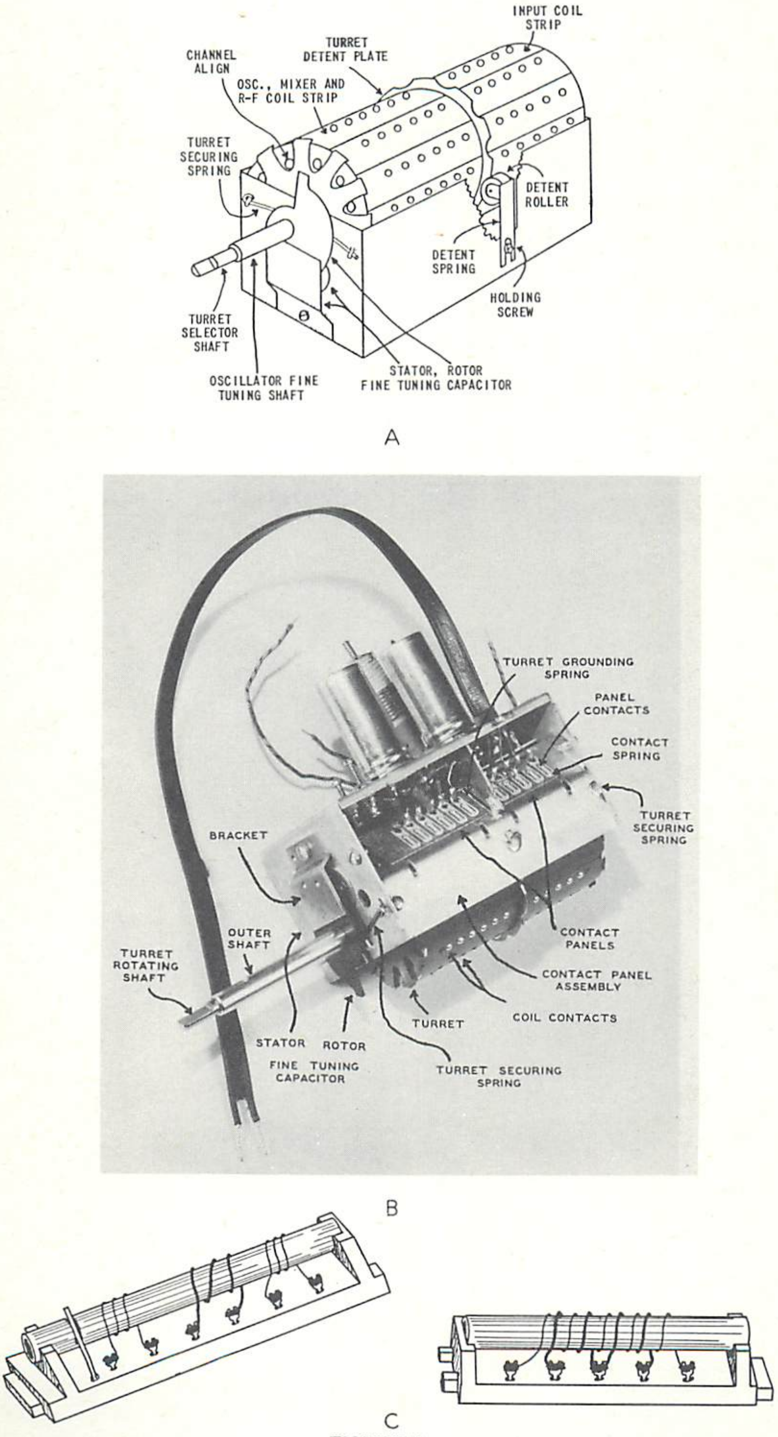
Many of the VHF tuners have some kind of provision for UHF adaption which will be described in a later lesson on UHF tuners.

In the final analysis, the main objective of any tuner is to select and increase the amplitude of the channel signals, and convert these r-f carriers to intermediate frequencies for further efficient amplification in the following i-f stages of the receiver.

The next lesson will describe the video i-f circuits and show what requirements are needed for good picture reproduction.

* * *

STUDENT NOTES


INPUT COIL STRIP
TURRET DETENT PLATE
CHANNEL ALIGN
OSC., MIXER AND R-F COIL STRIP
TURRET SECURING SPRING
DETENT ROLLER
DETENT SPRING
HOLDING SCREW
TURRET SELECTOR SHAFT
OSCILLATOR FINE TUNING SHAFT
STATOR, ROTOR FINE TUNING CAPACITOR
TURRET GROUNDING SPRING
PANEL CONTACTS
CONTACT SPRING
TURRET SECURING SPRING
BRACKET
OUTER SHAFT
TURRET ROTATING SHAFT
CONTACT PANELS
CONTACT PANEL ASSEMBLY
COIL CONTACTS
TURRET
STATOR
ROTOR
FINE TUNING CAPACITOR
TURRET SECURING SPRING

A

B

C

FIGURE 1

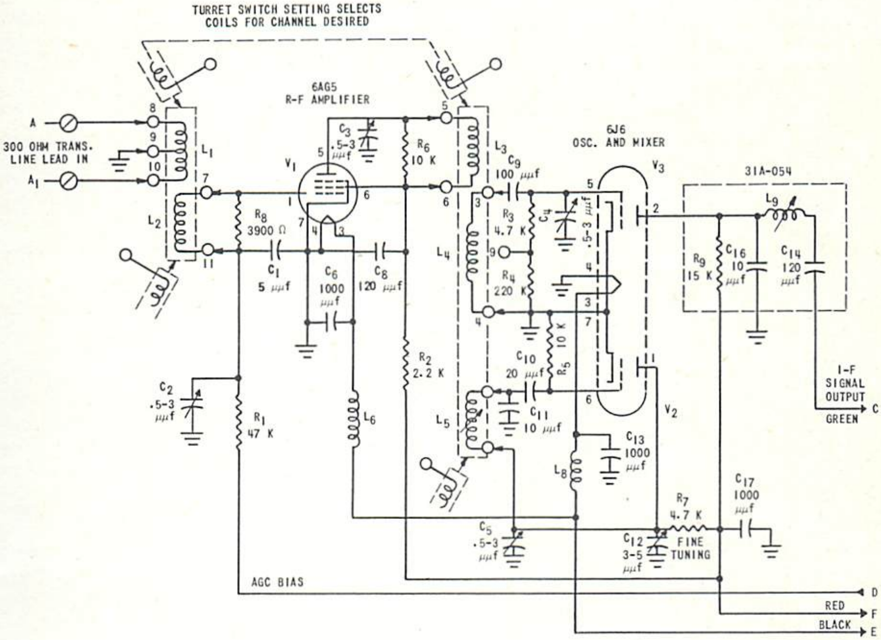


FIGURE 2

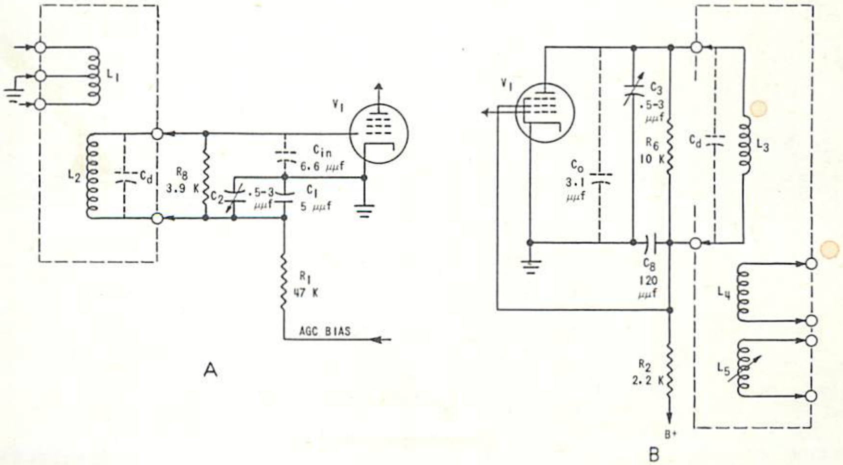
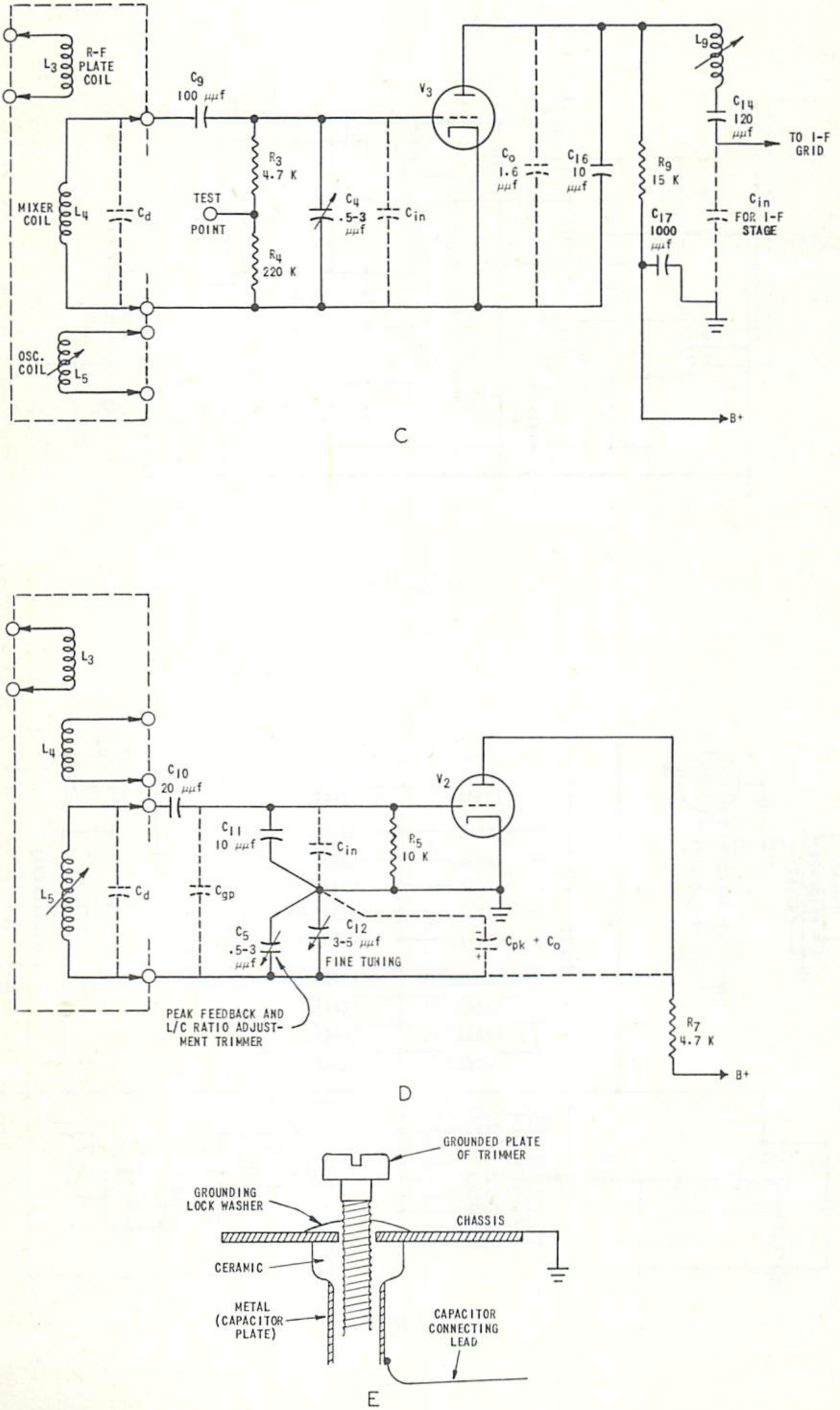


FIGURE 3


L3
R-F PLATE COIL
C9
100 μμf
V3
Co
1.6 μμf
C16
10 μμf
L9
C14
120 μμf
TO I-F GRID
R9
15 K
Cin
FOR I-F STAGE
C17
1000 μμf
MIXER COIL
L4
Cd
TEST POINT
R3
4.7 K
R4
220 K
C4
.5-3 μμf
Cin
OSC. COIL
L5
B+
L3
L4
C10
20 μμf
V2
C11
10 μμf
Cin
R5
10 K
L5
Cd
Cgp
C5
.5-3 μμf
C12
3-5 μμf
FINE TUNING
Cpk + Co
PEAK FEEDBACK AND L/C RATIO ADJUSTMENT TRIMMER
R7
4.7 K
B+
GROUNDED PLATE OF TRIMMER
GROUNDING LOCK WASHER
CHASSIS
CERAMIC
METAL (CAPACITOR PLATE)
CAPACITOR CONNECTING LEAD

C

D

E

FIGURE 3

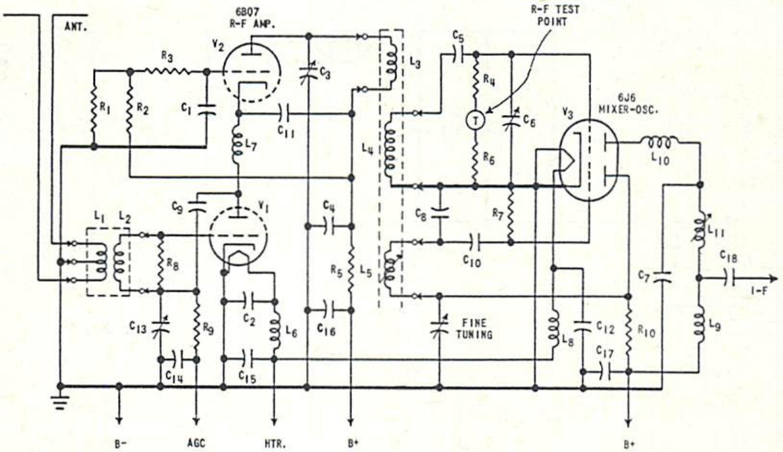


FIGURE 4

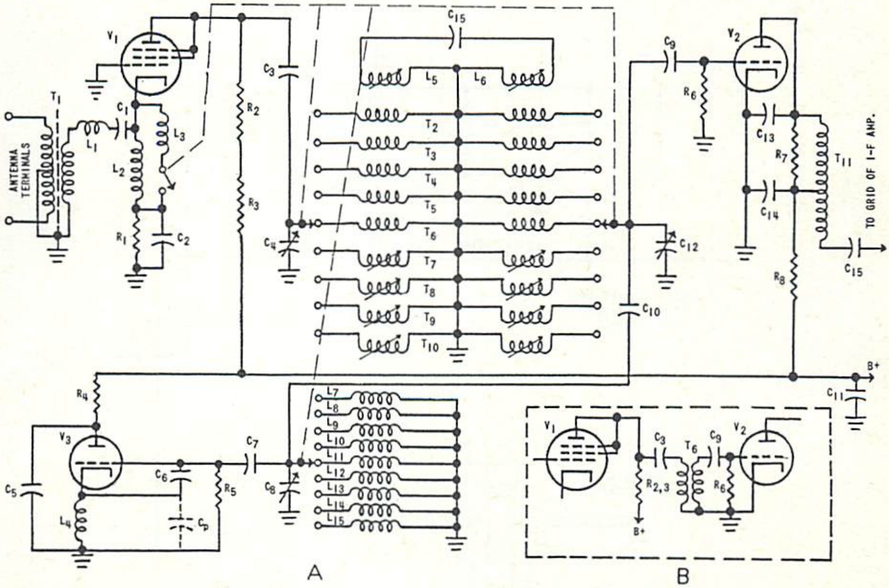


FIGURE 5

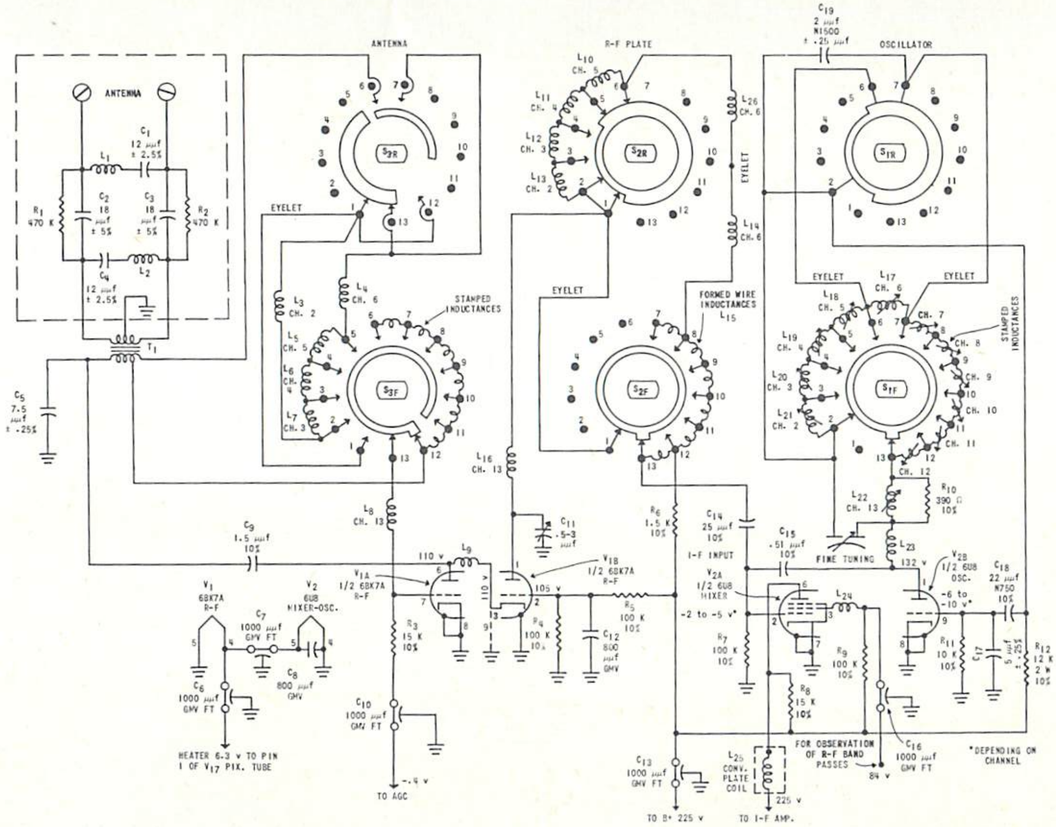

ANTENNA
C1 12 μμf ± 2.5%
L1
C2 18 μμf ± 5%
C3 18 μμf ± 5%
R1 470 K
R2 470 K
C4 12 μμf ± 2.5%
L2
T1
C5 7.5 μμf ± .25%
ANTENNA
S3R
EYELET
L3 CH. 2
L4 CH. 6
STAMPED INDUCTANCES
S3F
L5 CH. 5
L6 CH. 4
L7 CH. 3
L8 CH. 13
C9 1.5 μμf 10%
V1 6BK7A R-F
V2 6U8 MIXER-OSC.
C7 1000 μμf GMV FT
C8 800 μμf GMV
C6 1000 μμf GMV FT
HEATER 6.3 v TO PIN 1 OF V17 PIX. TUBE
V1A 1/2 6BK7A R-F
110 v
L9
R3 15 K 10%
C10 1000 μμf GMV FT
-.4 v
TO AGC
R-F PLATE
L10 CH. 5
L11 CH. 4
L12 CH. 3
L13 CH. 2
S2R
L26 CH. 6
EYELET
L14 CH. 6
EYELET
FORMED WIRE INDUCTANCES L15
S2F
L16 CH. 13
C11 .5-3 μμf
V1B 1/2 6BK7A R-F
105 v
R4 100 K 10%
C12 800 μμf GMV
R5 100 K 10%
R6 1.5 K 10%
C13 1000 μμf GMV FT
TO B+ 225 v
C19 2 μμf N1500 ± .25 μμf
OSCILLATOR
S1R
EYELET
L17 CH. 6
EYELET
L18 CH. 5
L19 CH. 4
L20 CH. 3
L21 CH. 2
S1F
CH. 7
CH. 8
CH. 9
CH. 10
CH. 11
CH. 12
STAMPED INDUCTANCES
L22 CH. 13
R10 390 Ω 10%
L23
FINE TUNING
C14 25 μμf 10%
I-F INPUT
C15 .51 μμf 10%
V2A 1/2 6U8 MIXER
-2 to -5 v*
L24
R7 100 K 10%
R8 15 K 10%
R9 100 K 10%
L25 CONV. PLATE COIL
225 v
TO I-F AMP.
FOR OBSERVATION OF R-F BAND PASSES
84 v
C16 1000 μμf GMV FT
132 v
V2B 1/2 6U8 OSC.
-6 to -10 v*
C18 22 μμf N750 10%
R11 10 K 10%
C17 5 μμf ± .25%
R12 12 K 2 W 10%
*DEPENDING ON CHANNEL

FIGURE 6

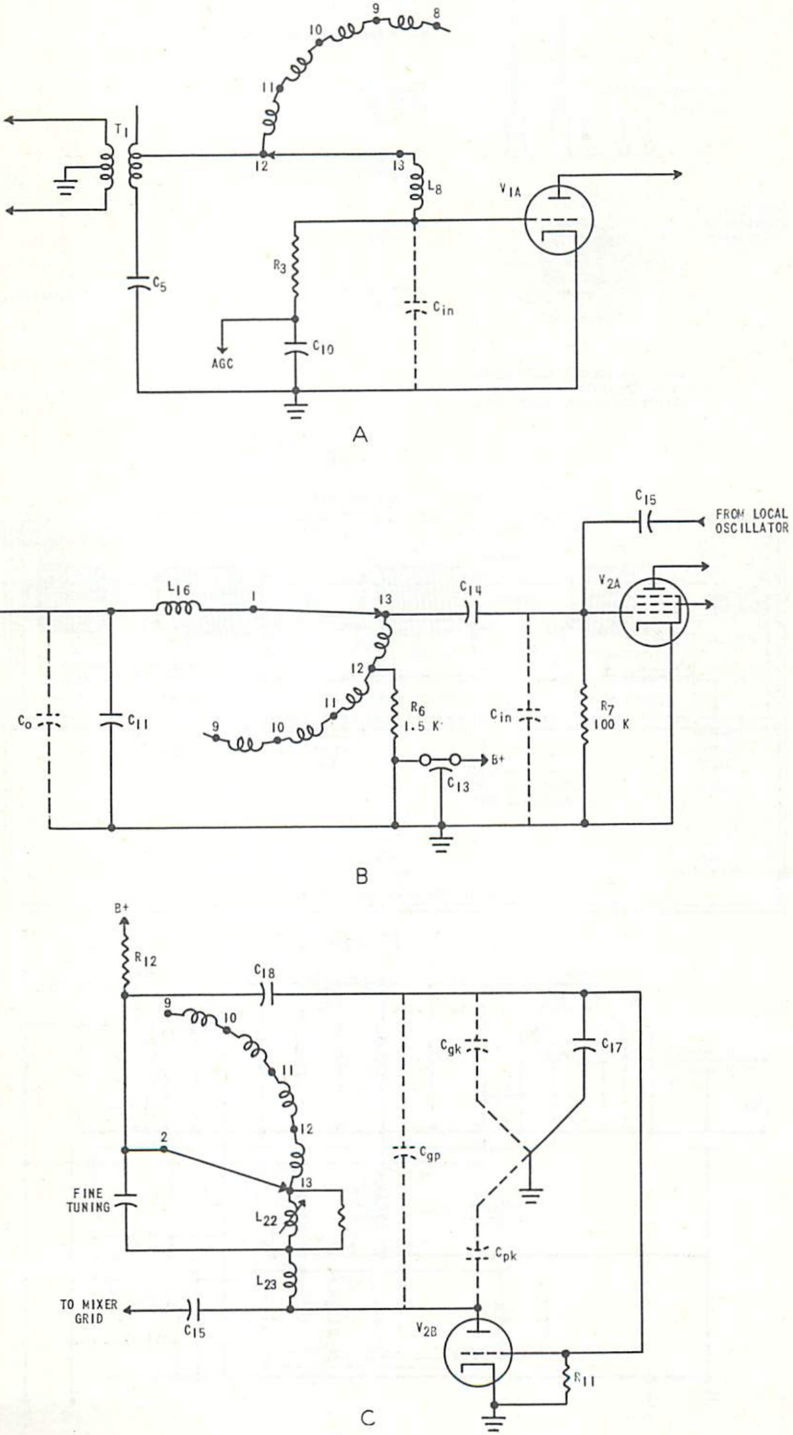
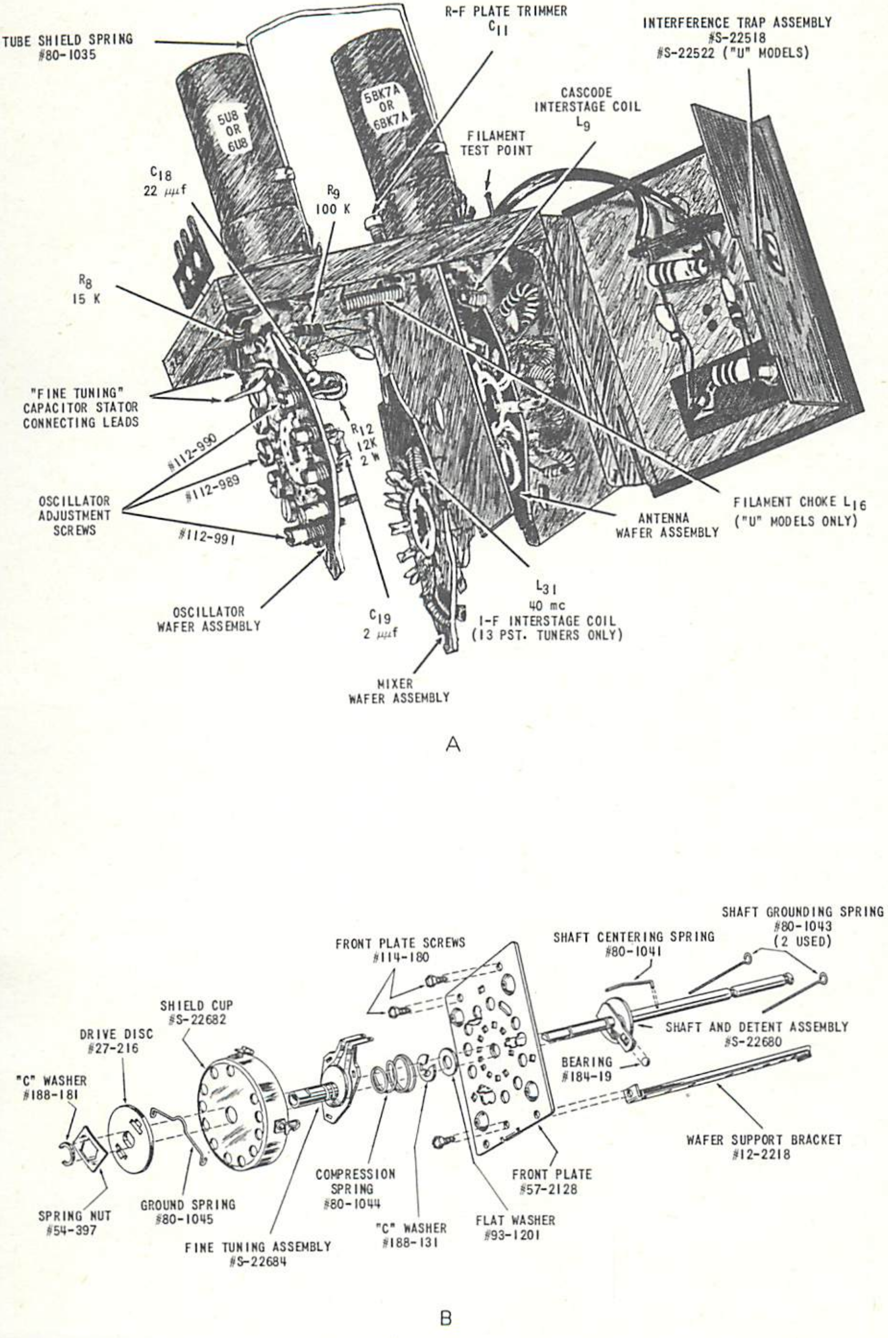

10
9
8
11
T1
12
13
L8
V1A
R3
C5
Cin
C10
AGC
A
C15
FROM LOCAL OSCILLATOR
L16
1
13
C14
V2A
V1B
12
11
R6
1.5 K
Cin
R7
100 K
Co
C11
9
10
B+
C13
B
B+
R12
C18
9
10
11
Cgk
C17
12
2
Cgp
13
FINE TUNING
L22
Cpk
L23
TO MIXER GRID
C15
V2B
R11
C

FIGURE 7


TUBE SHIELD SPRING #80-1035
R-F PLATE TRIMMER C_{11}
INTERFERENCE TRAP ASSEMBLY #S-22518 #S-22522 ("U" MODELS)
5U8 OR 6U8
5BK7A OR 6BK7A
CASCODE INTERSTAGE COIL L_9
FILAMENT TEST POINT
C_{18} 22 μμf
R_9 100 K
R_8 15 K
"FINE TUNING" CAPACITOR STATOR CONNECTING LEADS
R_{12} 12K 2 W
#112-990
#112-989
#112-991
OSCILLATOR ADJUSTMENT SCREWS
FILAMENT CHOKE L_{16} ("U" MODELS ONLY)
ANTENNA WAFER ASSEMBLY
OSCILLATOR WAFER ASSEMBLY
C_{19} 2 μμf
L_{31} 40 mc I-F INTERSTAGE COIL (13 PST. TUNERS ONLY)
MIXER WAFER ASSEMBLY
SHAFT GROUNDING SPRING #80-1043 (2 USED)
SHAFT CENTERING SPRING #80-1041
FRONT PLATE SCREWS #114-180
SHIELD CUP #S-22682
DRIVE DISC #27-216
"C" WASHER #188-181
SHAFT AND DETENT ASSEMBLY #S-22680
BEARING #184-19
WAFER SUPPORT BRACKET #12-2218
COMPRESSION SPRING #80-1044
FRONT PLATE #57-2128
SPRING NUT #54-397
GROUND SPRING #80-1045
"C" WASHER #188-131
FLAT WASHER #93-1201
FINE TUNING ASSEMBLY #S-22684

A

B

FIGURE 8

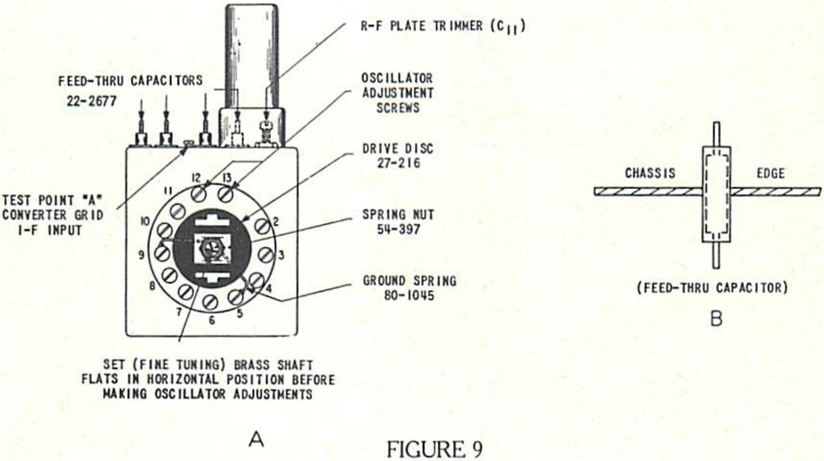


FIGURE 9

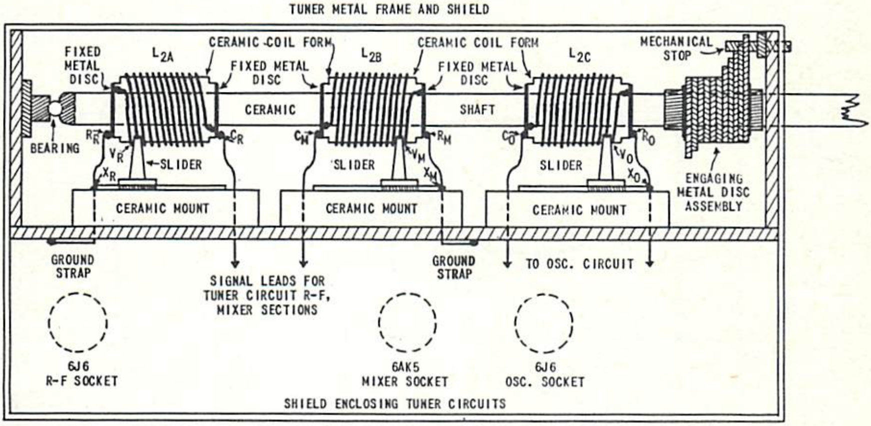


FIGURE 10

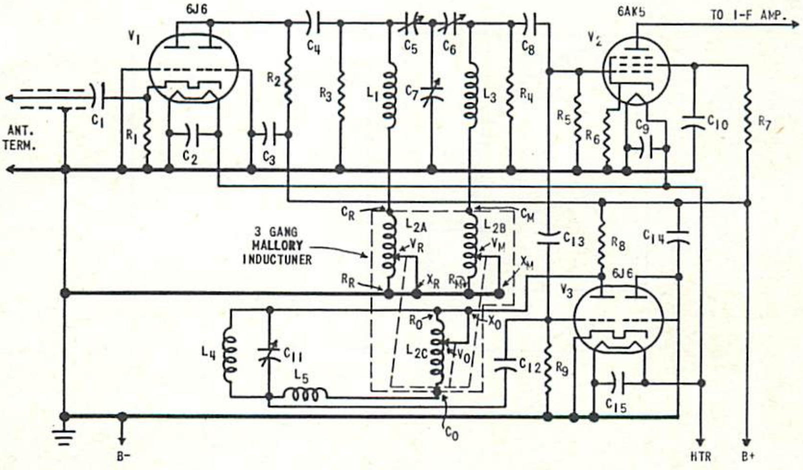


FIGURE 11

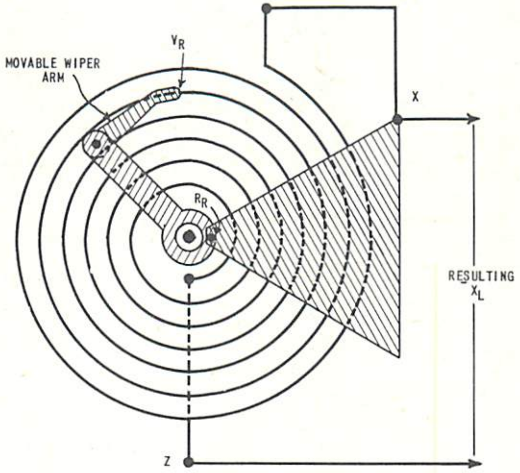
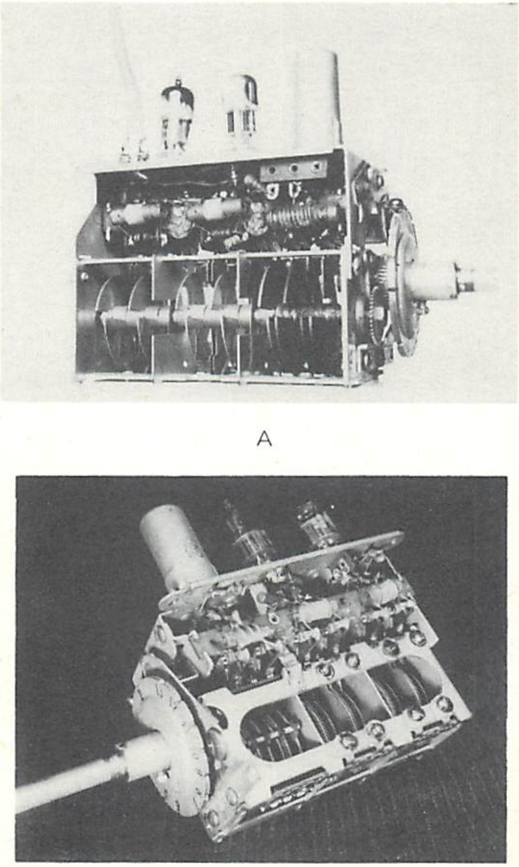


FIGURE 12



A

B

FIGURE 14

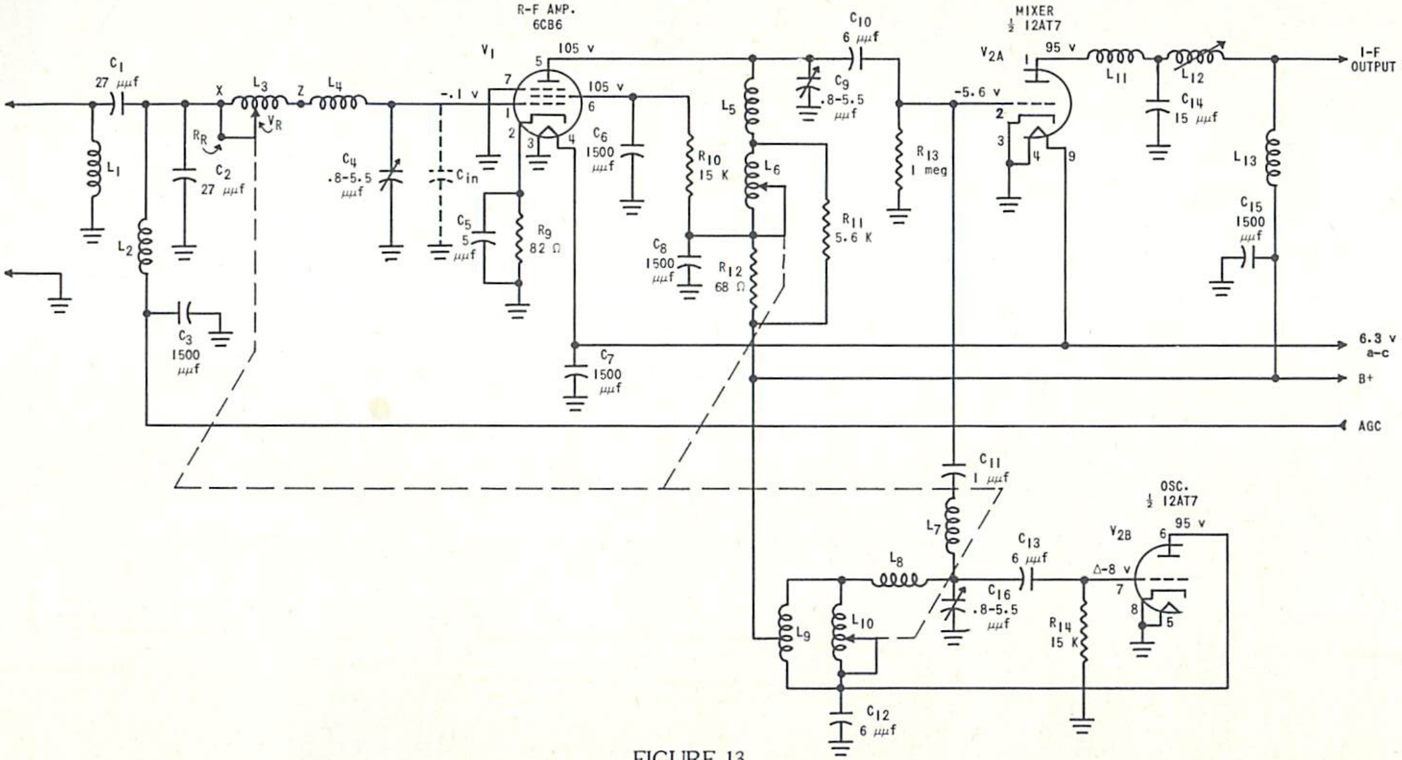

R-F AMP.
6CB6
V1
MIXER
½ 12AT7
V2A
OSC.
½ 12AT7
V2B
C1 27 μμf
C2 27 μμf
C3 1500 μμf
C4 .8-5.5 μμf
Cin
C5 5 μμf
C6 1500 μμf
C7 1500 μμf
C8 1500 μμf
C9 .8-5.5 μμf
C10 6 μμf
C11 1 μμf
C12 6 μμf
C13 6 μμf
C14 15 μμf
C15 1500 μμf
C16 .8-5.5 μμf
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
R9 82 Ω
R10 15 K
R11 5.6 K
R12 68 Ω
R13 1 meg
R14 15 K
RR
VR
X
Z
-.1 v
105 v
105 v
-5.6 v
95 v
95 v
Δ-8 v
1
2
3
4
5
6
7
8
9
I-F OUTPUT
6.3 v a-c
B+
AGC

FIGURE 13

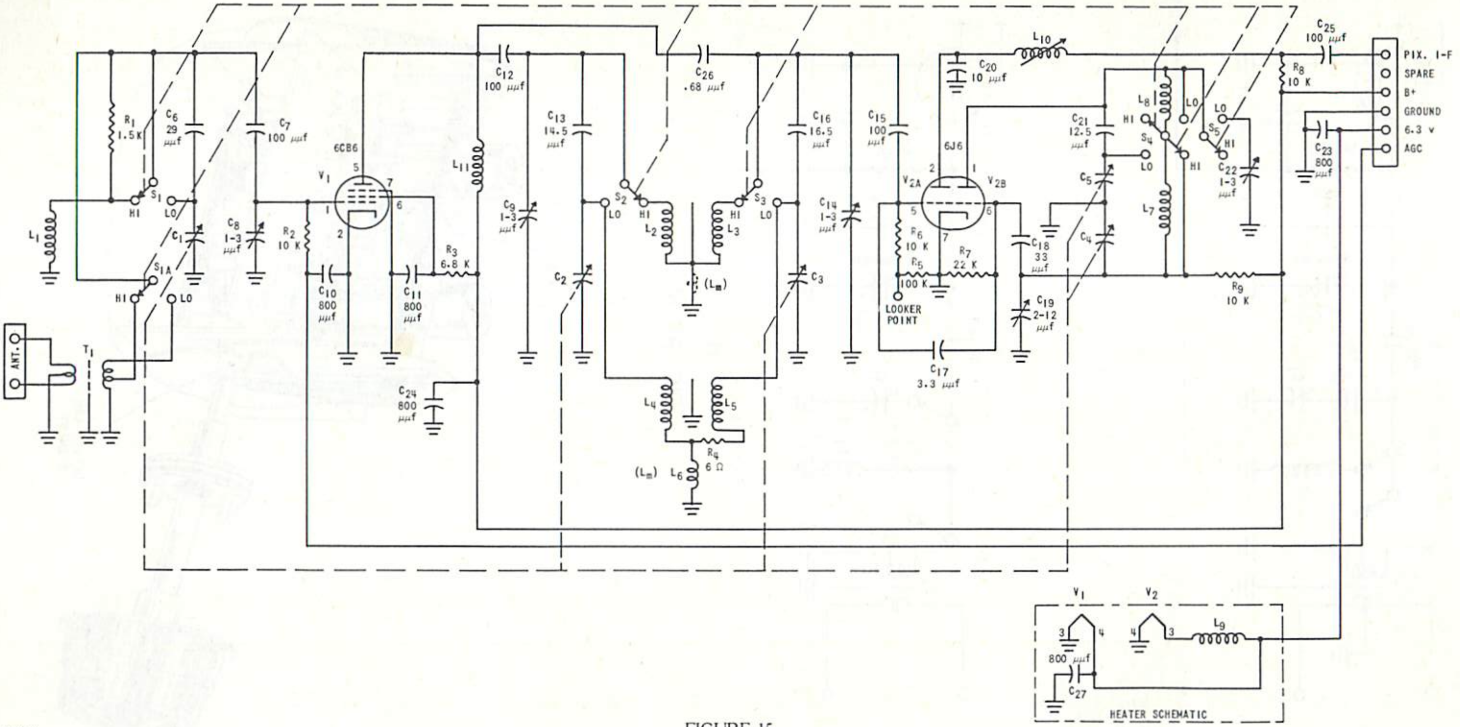

ANT.
T1
L1
R1
1.5 K
S1
HI
LO
S1A
HI
LO
C1
C6
29
μμf
C7
100 μμf
C8
1-3
μμf
V1
6CB6
5
7
1
2
6
R2
10 K
C10
800
μμf
C11
800
μμf
R3
6.8 K
C24
800
μμf
L11
C12
100 μμf
C9
1-3
μμf
C13
14.5
μμf
C2
C26
.68 μμf
S2
LO
HI
L2
S3
HI
LO
L3
(Lm)
C3
L4
L5
R4
6 Ω
(Lm)
L6
C16
16.5
μμf
C14
1-3
μμf
C15
100
μμf
V2A
6J6
2
1
V2B
5
6
7
R6
10 K
R5
100 K
LOOKER
POINT
R7
22 K
C17
3.3 μμf
C18
33
μμf
C19
2-12
μμf
C20
10 μμf
L10
C21
12.5
μμf
C5
C4
L8
HI
S4
LO
L7
LO
HI
S5
LO
HI
C22
1-3
μμf
R9
10 K
R8
10 K
C25
100 μμf
C23
800
μμf
PIX. I-F
SPARE
B+
GROUND
6.3 v
AGC
V1
3
4
800 μμf
C27
V2
4
3
L9
HEATER SCHEMATIC

FIGURE 15

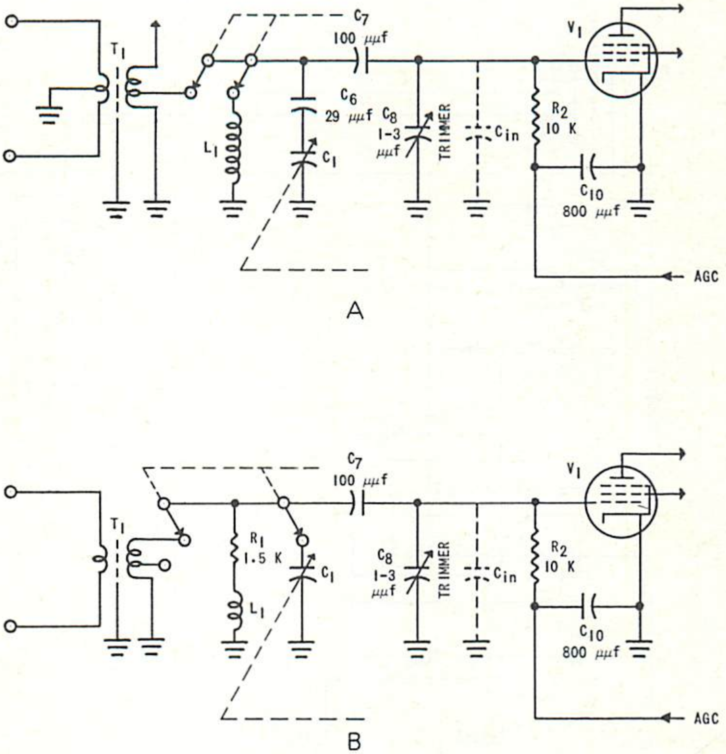


FIGURE 16

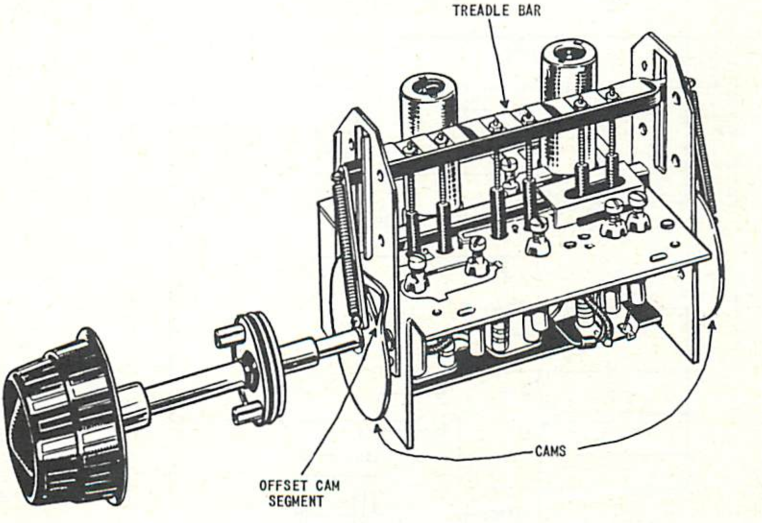
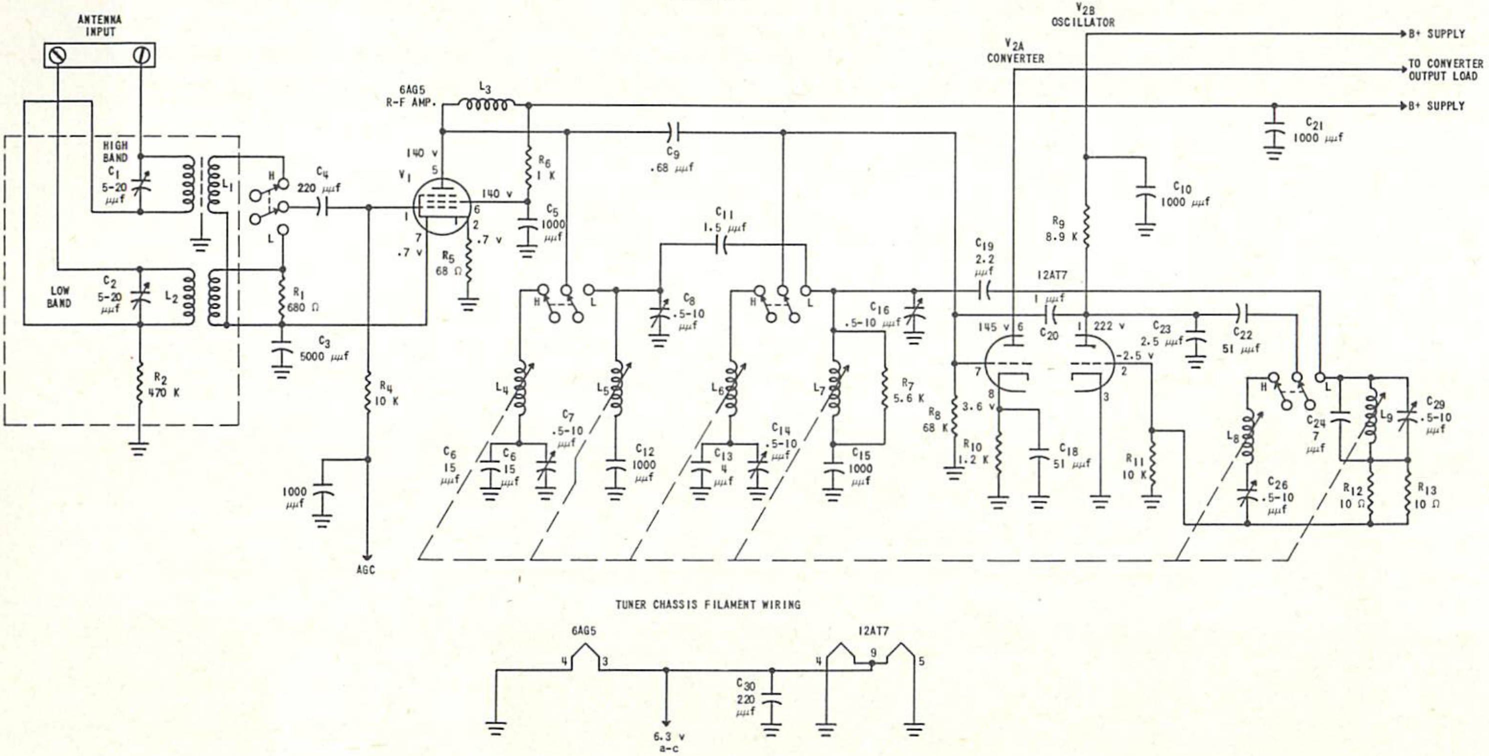


FIGURE 17


TUNER CHASSIS

TUNER CHASSIS FILAMENT WIRING

FIGURE 18

FROM OUR *Director's* NOTEBOOK

THE MAN WHO GETS PROMOTED

The ordinary fellow does an ordinary task,
He's mighty fond of "good enough" and lets it go at that;
But the chap who gets promoted, or the raise he doesn't ask,
Has just a little something more than hair beneath his hat.
The ordinary fellow lives an ordinary day,
With the ordinary fellow he is anxious to be quit;
But the chap who draws attention and the large weekly pay
Has a vision for the future, and is working hard for it.
The ordinary fellow does precisely as he's told,
But someone has to tell him what to do, and how and when;
But the chap who gets promoted fills the job he has to hold
With just a little something more than ordinary men.

—Edgar A. Guest

Yours for success,

W. C. DeVry
DIRECTOR

PRINTED IN U.S.A.